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CONSUMER SPATIAL BEHAVIOR
IN EDMONTON RETAIL TRADE AREAS

by



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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled Consumer Spatial Behavior in Edmonton Retail Trade Areas submitted by Derek James McCune in partial fulfilment of the requirements for the degree of Master of Business Administration.

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ABSTRACT

This thesis concerns itself with a test of a probabilistic model of consumer spatial behavior in the Edmonton area. The model, which was developed in a previous study, is based on gravitation principles with consumer time and size of the shopping area as the variable determining consumer choice of a shopping center.

The data required for the model was gathered from secondary sources and from a mail questionnaire sent randomly to Edmonton consumers. The result of the test of the model with this data was that the model was not adequate to explain the Edmonton situation. Other variables affecting the choice of a shopping center were then examined.

The final conclusion was that a predictive model of consumer spatial behavior must necessarily take into account socioeconomic and demographic variables.

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CHAPTER I

INTRODUCTION

Nature of the Study

The subject of this thesis is the determination of intra-urban retail trade areas. This is a necessary prerequisite for ascertaining the potential market demand for the products of retail firms or agglomerations of retail firms. Once the retail trade area has been delineated, its relevant characteristics such as the number of people, their income levels, and their living style among other things, can be analyzed to give a measure of the possible market demand for products. This information aids in policy decisions on such matters as expansions, modernizations, budgeting, range of merchandise offerings, and promotional activities of the retail firms. Thus estimates of trade areas and trade potentials of shopping facilities are essential to real estate investors, retail firms, land and traffic planning authorities, and others concerned with the development, operation, and utilization of such facilities.

The technique by which estimates of trade areas can be made vary from guesswork and intuition to the use of empirically derived mathematical models. It is possible that

work in this latter area can lead to standardized procedures which will allow estimates to be made quickly, accurately, and easily. This study will investigate retail trade areas and interactions in the city of Edmonton using a probabilistic model of consumer spatial behavior based on gravitation concepts.

Purpose of the Study

The determination of retail trade areas has traditionally followed either of two methodologies.¹ One has been to use subjective judgment based on observation of similar conditions from which generalizations have been drawn. The other has been the use of empirically derived mathematical formulations which are generally referred to as gravitation models. Gravitation models in retailing were first applied by William J. Reilly in 1929.² His ideas and concepts have since been expanded upon by P. Converse, F. Strohkarck and K. Phelps, L. W. Ellwood, R. B. Reynolds, A. F. Jung and D. L. Huff.³

¹David L. Huff, Determination of Intra-Urban Retail Trade Areas (Los Angeles: University of California, Graduate School of Business Administration, Division of Research, 1962), p. 6.

²William J. Reilly, Methods for the Study of Retail Relationships (University of Texas, Bureau of Business Research, Research Monogram, No. 4, 1929); William J. Reilly, The Law of Retail Gravitation (New York: William J. Reilly Company, 1931).

³Paul D. Converse, A Study of Retail Trade Areas in East Central Illinois (Urbana: University of Illinois Press,

Huff has used gravitation concepts in the construction of a model to describe the consumer spatial behavior in intra-urban retail trade areas.⁴ Two variables, the size of the shopping facility and the distance to the shopping facility for the consumer, were asserted by Huff as being sufficient to estimate a shopping area's utility to the consumer. Encouraging results were obtained by Huff in 1961 during an empirical test of the model in a suburban community in the Los Angeles Metropolitan area.

In 1966 Wiginton attempted to use Huff's model in the Vancouver area of British Columbia, but found that it was not applicable.⁵

The purpose of this study is to see whether the model will lend itself in the determination of retail trade areas in Edmonton and if not, what problems are inherent in the model.

1946); Paul D. Converse, "New Laws of Retail Gravitation, Journal of Marketing, Vol. XIV (October, 1949), p. 382; Frank Strohkarck and Katherine Phelps, "The Mechanics of Constructing a Market Area Map," Journal of Marketing, Vol. XII (April, 1948), pp. 493-6; Robert B. Reynolds, "A Test of the Law of Retail Gravitation," Journal of Marketing, Vol. XVIII (January, 1953), pp. 275-6; Leon W. Ellwood, "Estimating Potential of Proposed Shopping Centers," The Appraisal Journal, 22 (4) (October, 1954), pp. 581-9; A. F. Jung, "Is Reilly's Law of Retail Gravitation Always True," Journal of Marketing, Vol. XXIV (October, 1959), pp. 62-3; Huff, Determination.

⁴Huff, Determination.

⁵John C. Wiginton, An Empirical Test of A Probabilistic Model of Consumer Spatial Behavior (Vancouver: University of British Columbia, M.B.A. Thesis, 1966).

Limitations of the Study

Due to the nature of some of the variables involved, certain limitations in the study have arisen. First, the results are only valid for the Edmonton area. Second, due to the fact that Edmonton is a growing city, the results are only valid for a certain period in time. Lastly, as the study deals only with some shopping centers and some classes of shopping goods, it would be invalid to apply the results beyond these confines.

Definitions

In order to facilitate an understanding of the various terms which may arise throughout this study, the following list of definitions is furnished. The definitions and concepts used are generally those employed by Huff and Wiginton in order to provide a continuum between this study and theirs.

Spatial Behavior. This refers to the observable courses of action that consumers take with respect to their choice of a shopping center.⁶

Shopping Center. This refers to complementary and competing agglomerations of retail firms which are geographically contained.⁷ According to this definition, a shopping

⁶Huff, Determination, p. 12.

⁷Ibid.

center then can be either planned or unplanned. Shopping centers can be characterized by being either of the older type or of the modern type. Older type centers are generally unplanned ribbon or strip developments constructed in discontinuous stages over long periods of time. This study will concern itself with only one unplanned older center in Edmonton. This is the downtown area including the major department stores and the proximate small stores. The actual demarcation of this area is taken to be 104 Street on the west, 103 Avenue on the north, 100 Street on the east, and 100 Avenue and McDonald Drive on the south.

Modern type shopping centers fall into three categories: the regional centers, the suburban centers, and the neighborhood centers.⁸ Regional shopping centers are planned developments centered around one or more major department stores supported by a number of smaller retail outlets. It has good depth and breadth of merchandise and may be perceived by the consumer as an approximate equivalent to the downtown area. In Edmonton there are eight of these centers and it is with these and the downtown area this study is concerned. Suburban and neighborhood centers which are primarily concerned with convenience goods, will not be examined in this study.

⁸J. Ross McKeever, Shopping Centers Re-Studied: Emerging Patterns and Practical Experiences, Technical Bulletin No. 30, Part One (Washington: Urban Land Institute, February, 1957), p. 9.

Retail Trade Area. This is a geographical region containing the probable customers for certain goods or services.

Shopping Trip. This is an excursion to the downtown area and any of the regional shopping centers by a consumer with the intention in mind of purchasing shopping goods.

Shopping Goods. These are goods which the consumer feels are worth the time and effort involved in making comparisons in order to achieve a possible gain.

Plan of Presentation

Chapter II deals with a review of gravitation models in marketing from their beginnings with Reilly to their application in intra-urban situation.

Chapter III presents Huff's model and discusses the empirical tests by himself and Wiginton.

Chapter IV explains the procedures involved with obtaining the data in the Edmonton area, its tabulation, and its analysis.

Chapter V analyzes the responses from the questionnaire and looks at consumer spatial behavior in Edmonton.

Chapter VI summarizes the results of the study and offers some direction for further work in the area.

CHAPTER II

A REVIEW OF GRAVIMETRIC MODELS IN MARKETING

Reilly's Laws of Retail Gravitation

Social scientists have at times developed models to explain interactions between two spheres of human activity based on analogies to Newton's Law of Universal Gravitation. This law states that "any two bodies in the universe attract each other with a force which is directly proportional to the product of the masses of the two bodies and inversely proportional to the square of the distance between them." In mathematical form, this law becomes:

$$F \propto \frac{Mm}{r^2} \quad (11 - 1)$$

where M is the mass of one body, m is the mass of the other body, r is the distance between them, and F is the force that one body exerts on the other. The proportionality may be replaced by an equation by replacing the proportional sign with an equal sign and a constant of proportionality, G, known as the "universal constant of gravitation" to give the following:

$$F = G \frac{Mm}{r^2} \quad (11 - 2)$$

Generally, gravitational concepts of human interactions parallel the above in that they state an attracting force of interaction exists between two spheres of human activity and that it varies directly with some function of the population size of the two centers and inversely with some function of the distance between them. This relationship can be shown as follows:

$$I_{ij} = \frac{f(P_i, P_j)}{f(D_{ij})} \quad (11 - 3)$$

where I_{ij} is the interaction between center i and center j , P_i and P_j are the populations of centers i and j respectively, and D_{ij} is the distance between center i and center j . Both the preceding relationship and Newton's Law are only applicable to large masses. The behavior of individual molecules of matter is not normally predictable and similarly an unknown individual selected at random does not have predictable behavior. The assumption underlying the human interaction models is that in large groups, the interactions of the groups can be described mathematically.¹

In his analysis of retail trade undertaken in 1929 to attempt to determine a method for measuring the retail

¹A history and description of gravitation models in the social sciences will not be entered into here. If the reader is interested in this subject he is referred to G. A. P. Carrothers, "An Historical Review of the Gravity and Potential Concepts of Human Interaction," Journal of the American Institute of Planners, XXII (Spring, 1956), p. 94.

trade influence of a city, William J. Reilly noticed a relationship which reminded him of Newton's Law of Gravitation. This led to the development of what he termed the "law of retail gravitation." Stated in his own words this was as follows:

Two cities attract retail trade from any intermediate city or town in the vicinity of the breaking point approximately in direct proportion to the population of the two cities and in inverse proportion to the square of the distances from these two cities to the intermediate town.²

This statement can be expressed mathematically as follows:

$$\frac{B_a}{B_b} = \left(\frac{P_a}{P_b} \right) \left(\frac{D_b}{D_a} \right)^2$$

where B_a and B_b are the proportions of retail trade from the intermediate town attracted by cities a and b respectively, P_a and P_b are the populations of cities a and b respectively, and D_a and D_b are the distances from the intermediate town to cities a and b respectively.

The relationship appears to be based on only two factors: population and distance. Does this imply that other relevant determinants of retail trade flows were ignored? No, this is not necessarily the case. Although a great many factors actually attract retail trade to a city, and although the depth of retail assortments of merchandise

²Reilly, Law, p. 9.

and services may constitute a more immediate source of attraction for such trade, population may tend to reflect such assortments and may represent the best general index of trade attraction. Similarly other factors than distance may tend to repel retail trade but distance alone is superior as a general index of repulsion.³ Reilly's view of using these proxy variables as the independent variables in his law was as follows:

In other words, the evidence secured in our national study shows that the population of a city and the distance from that city to another comparable city are the primary factors that condition the retail trade influence of that city; that population and distance are reliable indexes of the behavior of other factors; that other factors are either so closely related to, or so directly dependent upon, these two primary factors that the effects of the dependent factors tend to balance out when cities are compared on the basis of population and distance.⁴

Reilly did not come out at once with Equation 11 - 4 but rather with the following general one:

$$\frac{B_a}{B_b} = \left(\frac{P_a}{P_b} \right)^N \left(\frac{D_b}{D_a} \right)^n \quad (11 - 5)$$

He then stated his problem was to determine approximate values for the exponents N and n. The value of N was found by Reilly to be one on the basis of studies which he did not present.

³Ronald R. Gist, Retailing: Concepts and Decisions (New York: John Wiley and Sons, Inc., 1968), p. 168.

⁴Reilly, Law, pp. 31-32. Reilly did not present the "evidence secured."

Apparently he found "that a city with twice the population of another adjacent city enjoys about twice as much outside business in the territory between two cities and that a city five times the population of another adjacent city enjoys about five times as much outside trade in the intermediate territory."⁵

The determination of n was carried out in an interesting way. Reilly states:

We drove along the main automobile highways connecting larger cities and called upon the secretary of the Retail Credit Men's Association in intermediate cities and towns. On the basis of the records of credit inquiries kept in these offices, we were able to find that point at which the preponderance of retail trade ceased to flow in the direction of the city we had left and began to flow in the direction of the city we were approaching.⁶

With the breaking point town determined in this manner, Reilly could learn D_a and D_b from highway maps and P_a and P_b from census lists and then solve for n . This was done for 255 cases with the results shown in Table I and Figure I. On the basis of this distribution Reilly concluded that "a clear mode occurs in the range 1.51 - 2.5 which shows that the exponent of the distance is nearer to the second power than any other even power."⁷ It must be remembered though, that the power two normally used is a mode and does represent a distribution.

⁵George Schwartz, Development of Marketing Theory (Cincinnati: South Western Publishing Company, 1963), p. 18.

⁶Reilly, Law, p. 64.

⁷Reilly, Methods, p. 50.

Reilly then computed the location of the breaking point towns between 30 pairs of trading centers using Equation 11 - 4. A later field study to check the computations, showed that his law gave startlingly accurate predictions.

Converses's Contributions

Converses used Reilly's law as the basis of his studies of the movement of retail trade. He refined the results of Reilly's studies as well as developing new measures of the movement of retail trade among cities.⁸ From Equation 11 - 4, Converses derived the "breaking point" formula

$$D_b = \frac{D_a + D_b}{1 + \sqrt{\frac{P_a}{P_b}}} \quad (11 - 6)$$

According to Converse, the equation can be used to determine the boundaries of a city's normal trading area without performing any field work, provided that the difference between P_a and P_b is relatively small.

Another law of gravitation developed by Converse to cover situations where a small town loses a considerable amount of trade to one or more larger towns can be stated as

⁸By retail trade, Reilly apparently meant purchases of shopping goods, specialty goods, and convenience goods. On the other hand, Converse used the term to refer only to purchases of shopping goods, principally fashion goods.

TABLE I

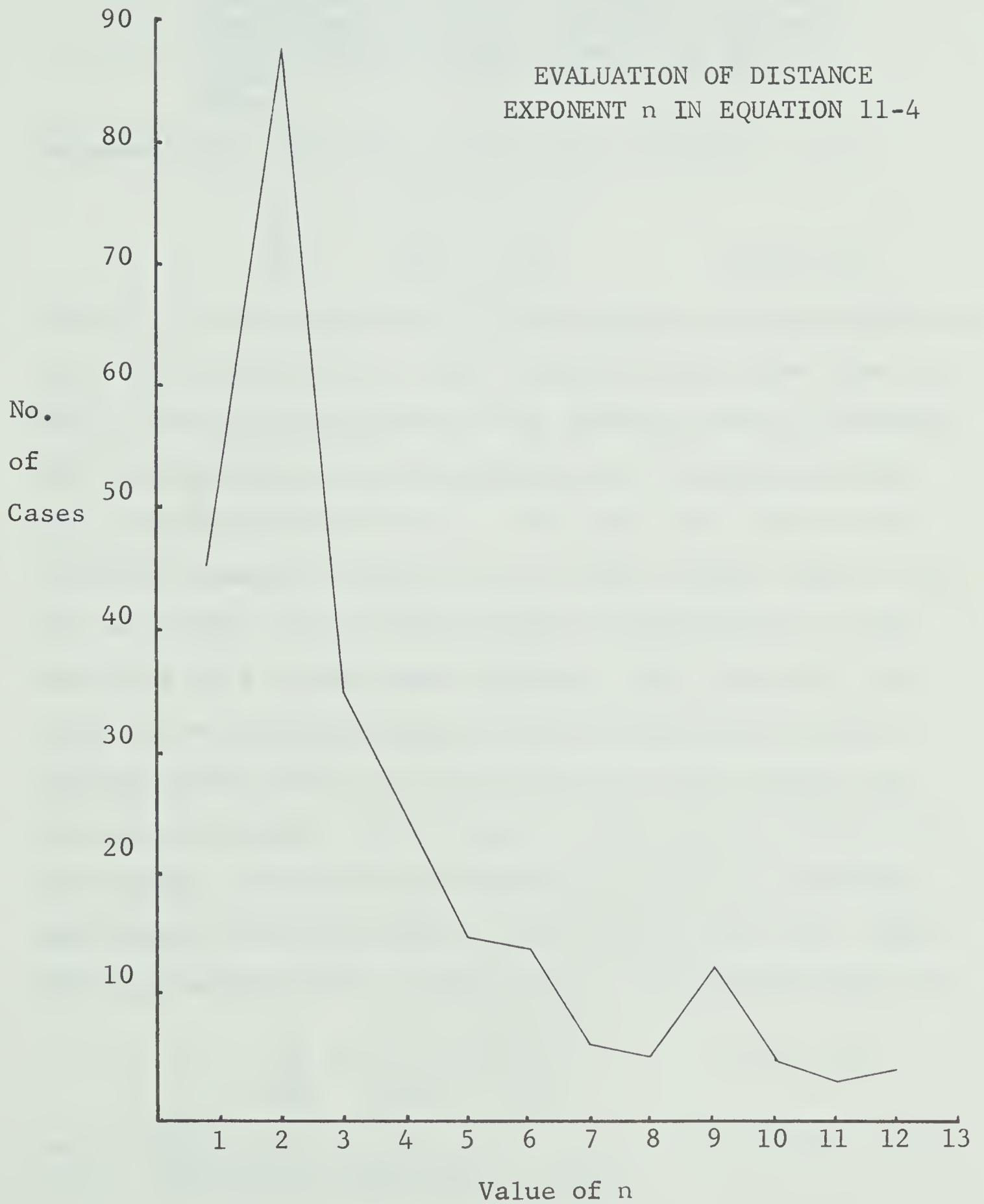
EVALUATION OF DISTANCE EXPONENT n IN EQUATION 11-4

<u>Value of n</u>	<u>No. of Cases</u>
0.00 - 1.5	45
1.51 - 2.5	87
2.51 - 3.5	35
3.51 - 4.5	24
4.51 - 5.5	15
5.51 - 6.5	14
6.51 - 7.5	6
7.51 - 8.5	5
8.51 - 9.5	12
9.51 - 10.5	5
10.51 - 11.5	3
11.51 - 12.5	4

Total cases = 255

Source: George Schwartz, Development of Marketing Theory
 (Cincinnati: South-Western Publishing Company,
 1963), p. 19.

FIGURE I



follows:

A trading center and a town in or near its trade area divide the trade of the town approximately in direct proportion to the populations of the two towns and inversely as the squares of the distance factors, using ⁹4 as the distance factor of the home town.

Mathematically the above relationship becomes:

$$\frac{B_a}{B_b} = \left(\frac{P_a}{H_b} \right) \left(\frac{4}{d} \right)^2 \quad (11 - 7)$$

where B_a is the proportion of trade going to the outside town, B_b is the proportion of trade retained by the home town, P_a and H_b are the populations of the outside town and the home town respectively, d is the distance to the outside town, and 4 is the inertia factor. If a small town lost a considerable amount of trade to two or more larger towns, then the proportion lost to these towns is determined by using multiples of 4 as the total inertia. Thus if a town lost trade to two centers, Converse would have used 8 as the inertia factor, and if it lost trade to three centers he would have used 12. In the case of some large centers such as Chicago, Converse found that due to parking congestion, the inertia factor for town in the vicinity was 1.5. This led to a modification of Equation 11 - 7 in these cases to:

$$\frac{B_a}{B_b} = \left(\frac{P_a}{P_b} \right) \left(\frac{1.5}{d} \right)^2 \quad (11 - 8)$$

⁹Converse, "New Laws," p. 382.

Equations 11 - 4 and 11 - 6 were also modified in order to increase predictive accuracy in situations where a trading center is more than 20 times the population of a relevant intermediate town. The results were:

$$\frac{B_a}{B_b} = \left(\frac{P_a}{P_b} \right) \left(\frac{D_b}{D_a} \right)^3 \quad (11 - 9)$$

$$D_b = \frac{D_a + D_b}{1 + \sqrt[3]{\frac{P_a}{P_b}}} \quad (11 - 10)$$

Equations 11 - 4, 11 - 6, 11 - 7, 11 - 8, 11 - 9, and 11 - 10 are taken as a group to be the laws of retail gravitation.

Tests of the Laws of Retail Gravitation

As was previously mentioned Reilly tested his law on 30 pairs of retail trading centers and found it accurate. Converse published two studies in which he tested the laws of retail gravitation.¹⁰ In them he calculated a coefficient of correlation between the predictions made and the actual situation determined by survey. These correlations, which were -0.88 and -0.93, convinced Converse of the validity of the laws although he cautioned:

¹⁰Converse, A Study, pp. 23-54; and Converse, Retail Trade, pp. 13-18.

It should not, however, be concluded that the law will measure the movement of trade with such accuracy in all territories. The towns included in the computations used here are in a territory in which the primary trading centers are considerably larger than the intermediate towns. In areas where there is less difference in size between the primary and secondary trading centers or between the trading centers and the towns from which they draw trade, the law of retail gravitation may perhaps not predict the movement or trade with the accuracy found in the territory here studied.¹¹

He also suggested that the law should only be applied in towns in the vicinity of the breaking point between larger towns, and that it should only be applied to the delineation of trading area for shopping goods and particularly fashion goods.¹²

R. Reynolds carried out tests of the law of retail gravitation in 1935 and 1949 for such commodities as groceries, eggs and poultry, movies, farm machinery, lumber and cement, physicians' services, women's coats and dresses, men's good shoes, and men's suits.¹³ Immediately it is obvious that Reynolds did not confine his studies to shopping goods as suggested by Converse. Reynolds found that the law did not hold for such goods as groceries, eggs and poultry, movies, lumber and cement, and physicians' services, but did hold for the shopping goods with correlation coeffic-

¹¹Ibid., p. 18.

¹²Ibid., p. 26.

¹³Reynolds, "A test."

ients of -0.75 to -0.90.¹⁴

A. F. Jung presented, in 1959, an instance which he maintained contradicted Reilly's law.¹⁵ The case involved residents of Columbia, Missouri favoring Kansas City merchants when the law predicted St. Louis merchants would be favored. Reilly countered Jung's study by saying that it did not invalidate his general law but rather invalidated a judgment that $N=1$ and $n=2$ as regards to the pulls of St. Louis and Kansas City on Columbia. The law of retail gravitation is accurate on the average and the fact that in one instance it did not predict correctly does not invalidate it, especially considering the number of times it has predicted correctly.¹⁶ Too often n is assumed to be two when actually this is only a model value.

Recent Developments in the Field

Recent developments in the applications of the law of retail gravitation have been to estimate trading areas of shopping centers within cities. In these intra-urban situations, important modifications have been necessary in the law. One modification, developed by the Curtis Publishing Company, is to substitute the square footage of each retail center for

¹⁴Ibid., pp. 275-276.

¹⁵Jung, "Is Reilly's Law."

¹⁶Schwartz, Development, p. 29.

population, and the travel time between retail centers for physical distance.¹⁷ The choice of square footage and travel time are again examples of proxy variables. The Curtis model has a number of drawbacks in that it only applies to consumers at or near the breaking points, and that it assumes that a consumer is making a choice between only two retail centers.

In order to overcome this last point, probabilistic models have been developed by Casey and Huff.¹⁸ The advantages of these models is that they are able to incorporate theories of consumer choice within their framework. A more complete description of Huff's model will be given in the following chapter.

The last development to be considered is the model presented by Bucklin.¹⁹ This model is an attempt to put a more theoretical foundation under shopping behavior in ultra-urban situations. As such the model is relatively complicated with many more than two variables and requires a considerable amount of time, money and data to make it operational. Bucklin developed his model from one study and to date no replications of it have been carried out.

¹⁷Ellwood, "Estimating Potential."

¹⁸Harry J. Casey Jr., "The Law of Retail Gravitation Applied to Traffic Engineering," Traffic Quarterly (July, 1955), pp. 313-321; Huff, Determination.

¹⁹Louis P. Bucklin, Shopping Patterns in an Urban Area (Berkeley: University of California, Institute of Business and Economic Research, 1967).

Limitations of Gravity Models

While gravity models have contributed to retail trade area analyses, they do have a number of limitations. The first is that calculation of breaking points to delimit retail trade areas, conveys an impression that a trading area has a fixed boundary. This obviously is not true and in reality a trading area represents a series of contours in which the proportion of consumers patronizing a given retail facility varies from zone to zone.²⁰ In an inter-urban case these contours will be quite sharp near the breaking point and in an intra-urban case, they will be more spread out.

A second limitation is related to the exponential n . Too often people have assumed n to be 2 when actually it is a range. In the intra-urban situation which will be discussed in the following chapter, there is no reason to assume at all that the exponential n is in the same range as in the inter-urban case.

Finally the gravity model, while being a fairly good predictive model, does not explain the underlying behavior. That is, it does not have much theoretical content. While there is not enough information available to actually regard Reilly's law as a true marketing law, there is also

²⁰Huff, Determination, p. 11.

not enough to suggest rejection of it. Until such time as improved theories of consumer spatial behavior are available, Reilly's law will remain a valuable aid in marketing.

CHAPTER III

A PROBABILISTIC MODEL OF CONSUMER SPATIAL BEHAVIOR

Huff's Probabilistic Model

The first applications of gravitation principles to the intra-urban situation were only able to deal with consumers at or near the breaking points and with choices of between one of two centers. David Huff's model is an attempt to overcome these limitations by adopting a view that consumer spatial behavior can be described as a probabilistic phenomenon.¹ In traditional economic theory, it is maintained that a consumer either always chooses the most desirable alternative with probability 1, or is indifferent among several equally desirable alternatives, each with an equal probability.² All other alternatives are given a zero probability. Huff maintains that the consumer is not able to discriminate among choices perfectly and is thus unable to maximize in the sense of choosing one

¹Huff, Determination, p. 4.

²Ibid., p. 16.

alternative exclusively.³ Instead the consumer will tend to choose among alternatives in some constant proportion and from this, a relative utility can be assigned to each alternative. This "utility" is different from the way it is normally used in classical theory. There, utility is identical with the rank of an alternative and that alternative with the highest rank is chosen. In Huff's study utility is proportional to the probability of being chosen.⁴

Huff asserts that the size of a shopping center measured in terms of square footage of selling space and the travel time involved in getting from a consumer's travel base to a shopping are sufficient to estimate a shopping center's utility to a consumer. He then hypothesizes "that the probability of a consumer patronizing

³Huff, Determination, p. 16. He gives two reasons for this. One is that if a consumer perceives only small differences among alternative choices, he will find it difficult to discriminate among them and hence somewhat randomly. The other is that the consumer is uncertain as to the true payoffs associated with each alternative and tends to check his intuitive choice by also making choices from other alternatives.

⁴To illustrate his meaning of utility, Huff gives an example of consumer planning to choose one of four shopping centers j_1, j_2, j_3 , and j_4 . The consumer perceives the relative utilities associated with each of the choices to be in the proportion 1:2:3:4. He will not select j_4 exclusively in this situation but will tend to choose it about $4/(1+2+3+4) = 40$ percent of the time if the choice situation is repeated a number of times. Huff, Determination, p. 16.

a shopping center is directly related to some increasing function of the time involved in travelling to a center."⁵

Development of the Model

In order to follow his derivation of his model, Huff sets down the following definitions:

1. A set of alternative shopping center choices which is represented as set J ;
2. A subset of alternative shopping center choices which is represented as J_0 . The subset J_0 of alternatives represents available alternatives which are in accord with a consumer's tastes and pretences. Any given alternative within the subset J_0 is represented as j (where $j = 1, \dots, n$); and,
3. A positive "payoff" function U_j is associated with each alternative shopping center indicating its "utility" to a consumer.⁶

With the preceding definitions, Huff sets forth the following proportions.

1. The probability P of a given alternative j being chosen from among all alternatives in the subset J_0 is proportional to U_j . This is,

⁵Ibid., p. 4.

⁶Ibid., p. 14. The development of Huff's model is adapted from the same source, pages 14 to 16.

$$P_j = \frac{U_j}{\sum_{j=1}^n U_j} \quad (111 - 1)$$

such that,

$$\sum_{j=1}^n P_j = 1; \text{ and, } 0 < P_j < 1.$$

2. The ratio between the probabilities of a consumer's choosing any one of two particular shopping centers does not depend on the existence of other centers. This ratio is called the ratio of utilities of the two centers to a consumer. Therefore,

$$\frac{P_{j1}}{P_{j2}} = \frac{U_{j1}}{U_{j2}} \quad (111 - 2)$$

3. The properties of the pair (P_{j1}, P_{j2}) that determine the utility in (U_{j1}, U_{j2}) are: (1) the "size" S_j of a given shopping center; and (2) the distance T_{ij} in time units from a consumer's travel base i to j .

4. The utility U_{ij} of a shopping center is directly proportional to the ratio S_j/T_{ij}^λ where λ is a constant. That is,

$$P_{ij} = \frac{U_{ij}}{\sum_{j=1}^n U_{ij}} = \frac{\frac{S_j}{T_{ij}^\lambda}}{\sum_{j=1}^n \frac{S_j}{T_{ij}^\lambda}} \quad (111 - 3)$$

where P_{ij} is the probability of a consumer at a given point of origin i travelling to a given shopping center j ; S_j is the size of a shopping center j ; T_{ij} is the travel time involved in getting from a consumer's travel base i to shopping center j ; and λ is a parameter which is to be estimated empirically to reflect the effect of travel time on various kinds of shopping trips.

5. The expected number of consumers at a given place i and shopping at center j is proportional to the number of consumers at i and to the probability that a consumer at i will select j for shopping. Therefore,

$$E(C_{ij}) = P_{ij} \times C_i = \frac{\frac{S_j}{T_{ij}^\lambda}}{\sum_{j=1}^n \frac{S_j}{T_{ij}^\lambda}} \times C_i \quad (111 - 4)$$

where $E(C_{ij})$ is the expected number of consumers at i that are likely to travel to shopping center j , and C_i is the number of consumers at i .

Huff notes that the utility of a shopping center to a consumer is based on many different factors and he says that "any attempt to measure the relative intensity or weight of all these factors would be doomed to failure."⁷ In order

⁷Ibid., p. 16.

to measure the utility of a center, Huff uses only two variables which are suggested by empirical evidence to be sufficient to enable predictions to be made reasonably well.⁸ The first of these is the number of items of the kind a consumer desires that are carried by various shopping centers. A consumer makes a large number of shopping decisions under conditions of uncertainty. This is to say that he does not know in advance whether a particular center will be able to fulfill a specified purchase, but he does have an idea of the probability that a center can satisfy his desires. Presumably, the greater the number of items carried by a center, the greater is a consumer's expectation that his shopping desires will be filled and the greater his willingness to travel further distances to these centers.⁹ If this function is a simple proportionality function, the relationship between the number of offerings and utility can be shown as in Figure II. It has been suggested, though, that this function may be curvilinear as shown by the alternative function in Figure II.¹⁰ As the calculating of the number of different items offered by various

⁸Carrothers, "An Historical Review."

⁹William J. Baumol and Edward A. Ide, "Variety in Retailing," Management Science, Vol. 3 (October, 1956), pp. 93 - 101.

¹⁰David L. Huff, "Ecological Characteristics of Consumer Behavior," Papers and Proceedings of the Regional Science Association, Vol. 7 (1961), pp. 19 - 28.

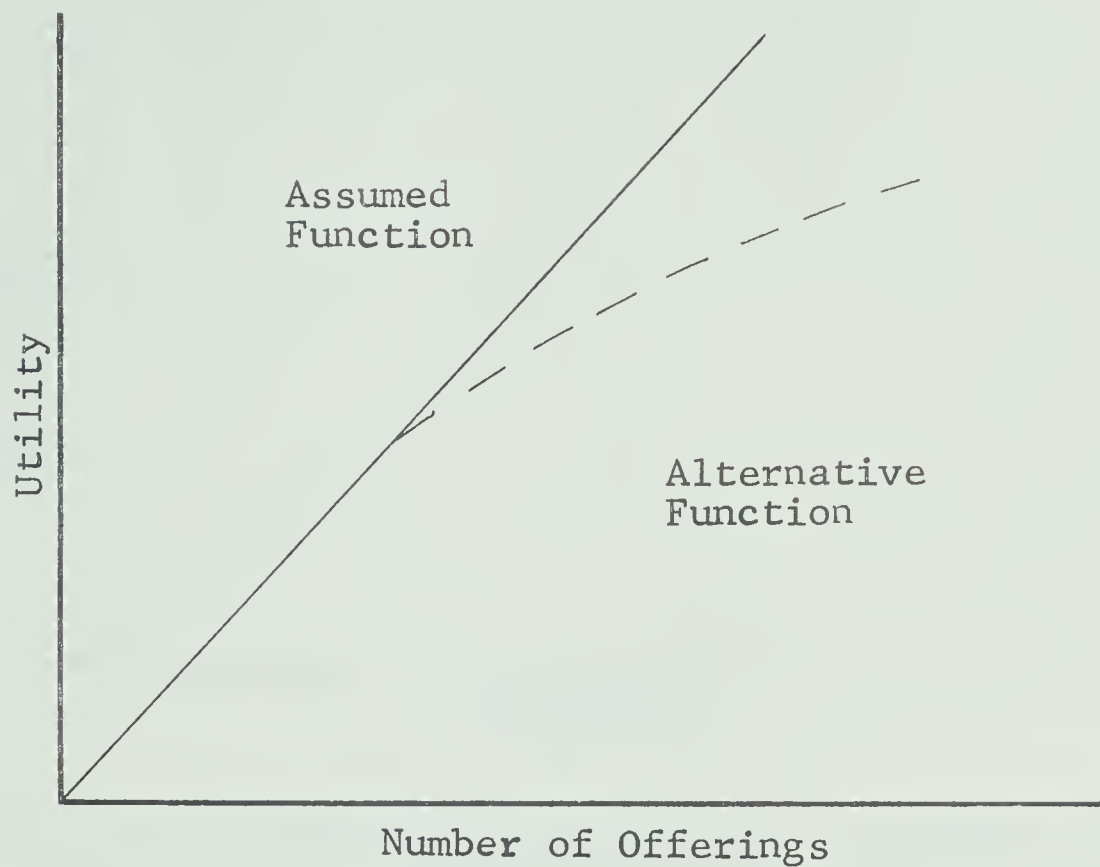


FIGURE II. The utility perceived by a consumer from increases in merchandise offerings.

shopping centers can be difficult, Huff has approximated this by the square footage of selling space devoted to the sale of items desired by a consumer.¹¹

The other variable Huff uses is that of the impact of travel time. As to distance to a shopping center increases, a consumer perceives disutility as a result of

¹¹Huff, Determination, p. 17.

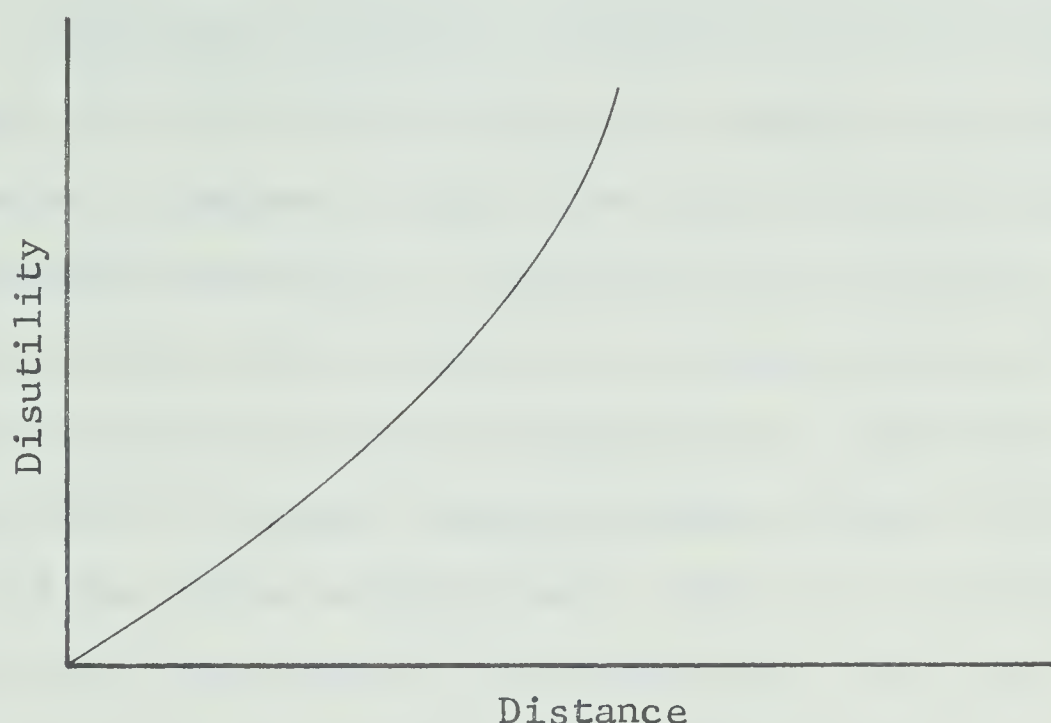


FIGURE III. The disutility perceived by a consumer from increases in distance.

the increased effort and expense involved in travelling to the center.¹² Figure III portrays this relationship.

Related to the variable of travel time is the differences consumers display in their willingness to travel various distances for different types of products.¹³ This accounts for the distance exponent λ . The determination of λ is carried out in the empirical test of the model.

¹²Ibid., p. 18.

¹³Ibid., p. 19. These variations can be attributed to the value differences that various goods and services possess to consumers.

Huff's Empirical Test of His Model

Huff used a suburban community in the Los Angeles Metropolitan Area as the setting for testing his model. He selected a judgment sample from each of three separate neighborhoods and mailed a questionnaire to them to determine their actual choices of shopping centers.¹⁴ The questionnaire is shown in Appendix A. Data was then obtained for 14 planned shopping centers within a 20 mile radius of the three neighborhoods. This data included both the selling areas of the centers and the travel times from each of them to each of the neighborhoods.¹⁵

With the basic data in hand, the exponential parameter, λ , had to be estimated. Huff did this by using a successive approximation solution involving a computer. He describes the sequential steps as follows:

1. Assume a particular value for λ which is greater than unity. Correspondingly, substitute the appropriate values for each of the appropriate alphabetic characters noted in the model and calculate the expected probabilities.
2. Compare the expected probabilities with the actual relative frequencies obtained from the survey data and calculate a correlation coefficient.

¹⁴Each neighborhood represents the i 's of the model. The criteria that Huff used in selecting the neighborhoods was that they should be approximately equal in terms of population density, and be fairly homogeneous in terms of income. This last factor was approximated by the value of dwelling units.

¹⁵The shopping centers represent the destinations or j 's of the model.

3. Continue to substitute incremental values for λ until the highest correlation coefficient is obtained which will represent the optimum value of the parameter.¹⁶

A flow chart illustrating the above sequence of steps, partially adapted from Huff, is shown in Appendix B.¹⁷

The correlation coefficient that Huff refers to is not the normal one used in regression analysis. The coefficient (as taken from Appendix B) is:

$$R = \sqrt{1 - \frac{\sum_{j=1}^n (C_{ij} - E(C_{ij}))^2}{\sum_{j=1}^n (C_{ij} - \frac{\sum_{j=1}^n C_{ij}}{N})^2}} \quad (111 - 5)$$

¹⁶Huff, Determination, p. 23. Huff also gives two rules he established in order to carry out the steps. One is that the expected numbers of trips (sample size times the established probability) to any given shopping center had to be equal to or greater than one-half a trip, and the other is that λ was to be estimated for each neighborhood separately.

¹⁷Huff explains the process in another way. He says that "if the actual consumer shopping center selections --- are compared to the expected selections generated from the model and are plotted against a 45° line of best fit, successive iterations using different exponential values will eventually yield a correspondence of the associated actual and expected values, they would be right on the 45° line." Ibid., p. 25.

The basis of this coefficient is that if there were no factors operating to cause some consumers to prefer one shopping center to another, then the choices would be randomly distributed among all the alternatives. This assumption is then compared to the observed behavior. If the model predicts the observed behavior exactly, the numerator will be zero and R will be 1. If the model provides no real improvement over the random behavior assumption, then the value of the fraction will approach 1 and R will be zero.¹⁸

Tables II and III summarize the results of Huff's study. Contrary to his expectations, the estimates of λ that Huff obtained varied from neighborhood to neighborhood for each commodity.¹⁹ The values of λ were then tested to see if the extreme values were due to factors other than sample variation. It was found that they were not and the mean values of 3.191 and 2.723 for clothing and furniture respectively were calculated.

Having estimates of λ for clothing and furniture, Huff shows how his model can be used for predictive purposes in determining the trade area of any given shopping center for these two product classes.²⁰

¹⁸Wiginton, An Empirical Test, pp. 89-90.

¹⁹Huff, Determination, p. 28.

²⁰Ibid., pp. 32-36.

TABLE II HUFF'S RESULTS OF OBSERVED AND EXPECTED BEHAVIOR OF CONSUMERS
WHO LAST PURCHASED CLOTHING

Shopping Center	Neighborhood 1		Neighborhood 2		Neighborhood 3	
	Observed	Expected	Observed	Expected	Observed	Expected
J ₁	71	70.76	148	144.28	143	141.49
J ₂	0	1.27	19	25.99	6	9.78
J ₃	0	1.04	4	3.10	2	2.05
J ₄	0	0.00	0	1.36	2	4.02
J ₅	5	2.60	38	13.73	21	2.07
J ₆	1	0.77	0	2.36	7	1.41
J ₇	0	0.00	2	2.03	6	3.22
J ₈	0	0.00	0	1.67	2	1.52
J ₉	0	0.00	0	0.89	0	0.00
J ₁₀	0	0.00	4	1.87	3	0.00
J ₁₁	1	0.99	2	3.44	3	1.52
J ₁₂	0	0.00	0	1.09	2	0.00
J ₁₃	1	0.78	0	10.58	6	35.92
J ₁₄	0	0.79	1	5.61	0	0.00

R = 0.99
λ = 2.889

0.96
3.690

Source: D. L. Huff, Determination of Intra-Urban Retail Trade Areas (Los Angeles: University of California, Graduate School of Business Administration, Division of Research, 1962), p. 26.

0.98
2.655

TABLE III HUFF'S RESULTS OF OBSERVED AND EXPECTED BEHAVIOR OF CONSUMERS
WHO LAST PURCHASED FURNITURE

Shopping Center	Neighborhood 1		Neighborhood 2		Neighborhood 3	
	Observed	Expected	Observed	Expected	Observed	Expected
J ₁	51	51.66	68	65.83	80	78.21
J ₂	0	1.50	4	16.72	1	7.43
J ₃	0	1.30	0	3.27	1	1.95
J ₄	0	0.00	0	1.33	0	3.05
J ₅	3	3.43	24	14.06	11	2.30
J ₆	6	0.98	6	2.55	12	1.38
J ₇	0	0.00	3	2.17	3	2.78
J ₈	0	0.00	1	2.00	0	1.50
J ₉	0	0.00	0	1.10	0	0.00
J ₁₀	2	0.00	16	2.02	4	0.00
J ₁₁	0	0.00	0	3.88	1	1.58
J ₁₂	0	1.31	0	1.50	1	0.00
J ₁₃	0	0.91	0	7.28	8	21.82
J ₁₄	0	0.91	6	4.29	0	0.00
R =	0.99	0.94			0.96	
λ =	2.542	2.115			3.247	

Source: D. L. Huff, Determination of Intra-Urban Retail Trade Areas (Los Angeles: University of California, Graduate School of Business Administration, Division of Research, 1962), p. 27.

Wiginton's Empirical Test of the Model

Huff stated that he considered his study a pilot one, and was planning a major empirical study.²¹ To date he has not published any results of such a study. The model has been tested, though, by John Wiginton in the Vancouver area of British Columbia.²² While Wiginton's methodology in regards to his data generation is not the same as Huff's the data is adequate for testing the model.²³ Before giving Wiginton's results, some interesting points he has uncovered concerning the model require comment.

The first concerns the correlation coefficient, R, given in Equation 111 - 5. In the computer program which estimates λ , shown in Appendix III, R^2 is determined before R from the following:

$$R^2 = 1 - \frac{\sum_{j=1}^n (C_{ij} - E(C_{ij}))^2}{\sum_{j=1}^n \left(\frac{\sum_{j=1}^n C_{ij}}{N} \right)^2} \quad (111 - 6)$$

²¹Ibid., p. 5.

²²Wiginton, An Empirical Test.

²³The questions concerning consumer shopping habits were part of a personal interview questionnaire being used mostly for another purpose, and the questionnaires were of two different types, although the questions concerned with Wiginton's study were the same on both types. The shopping centers related to the study included not only planned centers in the city but also the main downtown department stores. The consumers for the study were chosen randomly from 50 neighborhoods based on census divisions. Ibid., pp. 98-106.

In this equation it is possible for R^2 to be negative if the sum of squared deviations of estimated behavior from the actual behavior is greater than the sum of squared deviations of random behavior from actual behavior.²⁴ What this would mean is that the model is not able to fit the data as well as purely random behavior. In order to get around this situation, Wiginton included the subroutine found in Appendix C where reports if R^2 is negative, makes a large jump forward in λ , and then begins again.

The second feature regarding the model was found as a result of the type of computer program used by Wiginton.²⁵ Rather than just printing out the maximum R value and its corresponding λ , he included a plot function in order to see the manner in which R varied with λ . Such a graphical presentation allows a form of sensitivity analysis of the model in that it can be seen how rapidly R approaches its maximum value with either increasing or decreasing values of λ . Four distinct types of curves were found by Wiginton in the analysis of his data. These are shown with his notation in Figure IV.

Evaluation of Huff's data in this computer program shows that type II curves are found in all but the neighbor-

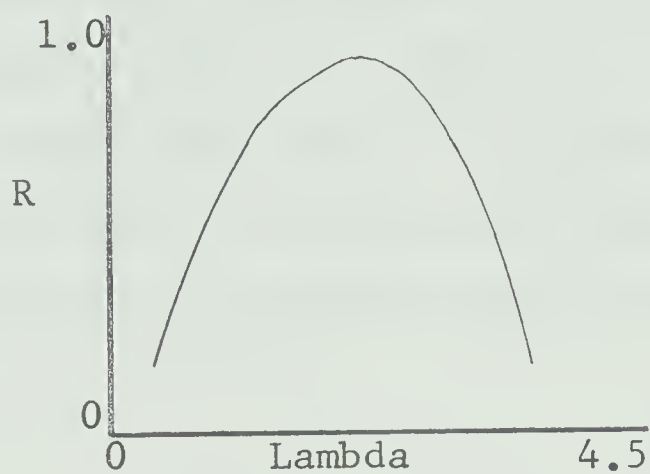
²⁴Ibid., pp. 108-109.

²⁵This program was checked by the present writer by using it to duplicate Huff's results from this data. Minor modifications to the original program were at first needed to meet the requirements of the University of Alberta computing system.

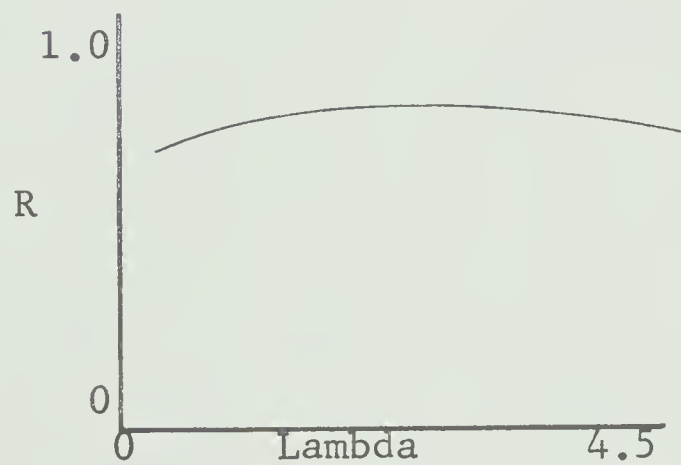
FIGURE IV

TYPICAL CURVES PRODUCED BY COMPUTER PROGRAM

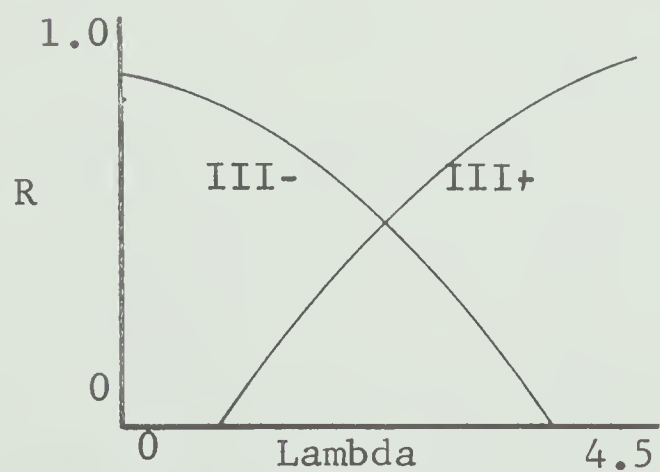
1. Type I



2. Type II



3. Types III- and III+



hood 2 clothing and furniture cases. Here the curves are of type I. The type II curves suggest that discussion of a particular value of λ is not completely appropriate and perhaps it should be referred to as a range.

The results of Wiginton's application of the model to his data are summarized in Table IV. Analysis of the λ and R values led him to reject the model.²⁶ Wiginton did not proceed any further and give or analyze the actual predictions made by the model as he perhaps might have done.

²⁶Wiginton, An Empirical Test, p. 110, and p. 114.

TABLE IV

TABULATION OF R AND LAMBDA FOR WIGINTON'S STUDY

Census Tract	Commodity A		Commodity B		Commodity C	
	R max	Lambda	R max	Lambda	R max	Lambda
00	0.735	4.32	III-		III+	
07	0.675	1.56	III+		III+	
08	0.910	1.96	undefined		III+	
09		III+	ni*		III+	
10	0.968	1.51	ni		III+	
11	0.318	1.11	undefined		ni	
12		undefined	0.610	2.31	0.473	1.34
14		III+	ni		0.646	1.22
15	0.954	2.45	ni		undefined	
16		undefined	III+		0.356	2.81
17	0.923	1.59	III+		III-	
19	0.795	2.93	ni		III-	
21	0.895	3.71	0.917	3.60	III-	
23		undefined	III-		undefined	
24		III-	III-		III-	
25	0.245	2.14	0.337	1.80	ni	
26		III-	ni		undefined	
27		III-	0.416	2.00	0.337	0.88
28		III-	III-		III-	
29		III-	III-		III-	
31	0.841	2.09	III-		III+	
32	0.885	3.54	ni		III+	
33	0.582	0.57	ni		0.959	2.17

TABLE IV (Continued)

Census Tract	Commodity A		Commodity B		Commodity C	
	R max	Lambda	R max	Lambda	R max	Lambda
34	0.902	1.40	ni		invalid	
35	0.639	1.40	0.792	1.83	0.926	1.28
36	0.887	2.39	0.848	1.30	0.552	1.12
39		III+				III+
40	0.895	1.75	0.475	1.71		III+
41	0.732	0.94	0.776	1.54	0.944	2.89
43	0.717	1.29	III-		0.944	2.70
44	0.773	0.98	ni		invalid	
45	0.820	0.76	ni		invalid	
46	0.964	1.97	0.982	2.98	invalid	
47	0.823	1.45	0.258	1.04	0.852	1.60
48	0.426	1.09	0.501	1.79	undefined	
49		III-	0.824	2.31		III-
51	0.531	2.92	ni		0.574	0.71
52		III-	ni		undefined	
53	0.709	1.39	ni		0.654	3.17
54	0.896	1.45	ni		0.752	3.31
55	0.901	2.27	III-			III+
56	0.929	2.50	0.701	3.19	0.823	3.88

* The designation ni means this census tract was not included for the particular commodity.

Source: John C. Wiginton, An Empirical Test of a Probabilistic Model of Consumer Spatial Behavior (Vancouver: University of British Columbia, M.B.A. Thesis, 1966) pp. 131-132.

CHAPTER IV

EMPIRICAL TEST OF THE MODEL IN EDMONTON

Research Strategy and Techniques

In order that Huff's model could be tested in the Edmonton area, it was first necessary to collect data on the spatial behavior of consumers, the shopping centers they used, and the travel times involved. These are respectively the C_{ij} 's, the S_j 's, and the T_{ij} 's for the model.

The determination of the C_{ij} 's was basically a process of finding from where consumers began their shopping trip and to where they travelled. This was done by means of a mail questionnaire, a copy of which is shown in Appendix E. The questions relevant to obtaining the C_{ij} 's are 1 and 2. Format for these questions was based on similar types used in Huff's questionnaire as shown in Appendix A. The population from which the recipients of the questionnaire were drawn was the Edmonton metropolitan area.

In selecting his neighborhoods Huff set down the criterion that they should be fairly homogeneous in terms

of income.¹ Using this and geographical location, the Edmonton metropolitan area was stratified into 37 strata. Each stratum contained a discrete number of civic census units so that the census rolls could be used for the selection of the sample. These 37 strata then represented the neighborhoods of i's from which the shopping trips originated. Figure F-1 of Appendix F shows the area under discussion with the census divisions and the 37 neighborhoods. In dividing up an area such as a city, it is difficult to have all neighborhoods homogeneous, but it is felt the divisions that were made fulfilled Huff's criterion.

The size of the sample for each stratum was a function of its population. One respondent was picked for each 500 population.² This number was arrived at as a result of two factors. The main factor was of cost considerations. With limited resources, only a set number of questionnaires could be sent out.³ The other factor

¹Huff approximated income by the value of dwelling units because of the difficulty in obtaining the former. Huff, Determination, p. 22. Information as to the value of dwelling units in the Edmonton metropolitan area was obtained from Edmonton Real Estate Board Cooperative Listing Bureau Ltd., M.L.S. Statistics 1969 (Edmonton: Confidential Report, 1970).

²In St. Albert and Sherwood Park, one respondent per 1000 was picked.

³Postage was paid both ways for the questionnaire. The cost per mailed questionnaire was 17.6¢ and the cost per returned questionnaire was 47.1¢.

was the number of replies necessary for the operation of the model. It was decided that about 250 replies would be adequate. A 25 percent return rate was assumed implying that about 900 questionnaires must be initially mailed out. The make-up of the sample is shown in Appendix F.

Selection of the respondents was performed using civic census rolls and a set of random numbers. These respondents were sent a questionnaire and their replies became the C_{ij} 's of the model. Appendix F gives the tabulation of the returned questionnaires.

Data concerning the shopping centres was collected from two sources. One was from published materials and the other was from personal contact with the appropriate people in the centers themselves. This data, part of which makes up the S_j 's of the model, is summarized in Appendix F.

The last data required for the operation of the model was the T_{ij} 's or the travel times required from each of the neighborhoods to each of the shopping centers. Huff does not state in his study how he measured this. Wiginton, though, gives a detailed description of his technique and it is the one which was followed in this study. The method as described by him is as follows:

---the area was laid out on a grid system along major traffic arteries. The length of each part of the grid was determined by driving along it, at normal speed, and measuring the time required with a stop watch. ---The distance measures thus obtained were marked on the grid on a map. The most

likely route from each neighborhood to each store was traced on the map, and the distance obtained by adding up the appropriate grid elements. Again, as in Huff's study, the center point of each neighborhood was assumed to represent the point of origin for all consumers in that neighborhood.⁴

The results of this exercise for the Edmonton area are given in Appendix F.

Results and Analysis

The return of questionnaires was much better than expected, reaching almost 38 percent. These returns represented 336 households containing 1317 people or one in 346 people in Edmonton. Tabulation of income and education data in Appendix G show that both of these variables tend to be higher than what would be expected. Thus the data may tend to be biased towards higher income and better educated people.⁵

Once all the data had been generated and collected, that which was relevant to the model was placed on IBM punch cards and run in the computer program of Appendix C.⁶ As

⁴Wiginton, An Empirical Test, p. 106.

⁵Possibly too, respondents placed themselves in higher categories to give a better impression of themselves.

⁶Two computer decks and languages were employed. The model was run in Fortran and used the answers of questions one and two from the questionnaire. All of the answers were coded in SPSS for the purposes of tabulation, correlation, and crosstabulation.

will be recalled this was the program designed by Wiginton to determine an exponent for the following expression:

$$E(C_{ij}) = \frac{\frac{S_j}{T_{ij}^\lambda}}{\sum_{j=1}^n \frac{S_j}{T_{ij}^\lambda}} \quad (1V - 1)$$

such that the λ chosen gave the closest prediction of $E(C_{ij})$ to the actual C_{ij} determined by the questionnaire. In effect the program attempts a goodness of fit of $E(C_{ij})$ to C_{ij} for a range of λ values and chooses that one which gives the best fit. The plotting function is included in order to test the uniqueness of the value of λ chosen. As well as giving the R and λ values for all neighborhoods, the predicted share of each shopping center for each neighborhood is printed out. Thus there are two approaches to evaluating the results given by the model. The first one is to examine the λ determinations.

Table V shows the estimates of the exponential parameter λ for each neighborhood along with its corresponding curve type and R value. It can be seen that 50 of 165 of the estimates were indeterminate. Those neighborhoods which consistently failed to provide estimates of λ were examined to see whether any distinctive features

could be found. This exercise did not provide any meaningful answers. Of the estimates that were obtained, wide variations were found. This condition is similar to that found by Wiginton. The range of estimates for λ for clothing in this study was 0.96 to 3.72, and the range for major household goods was 0.73 to 4.05.⁷ Means for these ranges can be calculated if the λ estimates can be assumed to be from the same statistical population. In order to see whether the extreme values could be included in the calculation of these means, the same test employed by Huff was used.⁸ This statistical criterion tests the hypothesis that the extreme values of λ are not due to factors other than sample variation. The statistic takes the following form:

$$r = \frac{\bar{X}_3 - \bar{X}_1}{\bar{X}_{k-2} - \bar{X}_1}$$

where $\bar{X}$ is one of k means arranged in order of size from the smallest to the largest and numbered from 1 to k .⁹ To test whether the largest mean is significantly larger than the

⁷Both Huff's and Wiginton's analysis focused primarily on these two categories as will this study.

⁸Huff, Determination, p. 23.

⁹W. J. Dixon and F. J. Massey, Jr., Introduction to Statistical Analysis (New York: McGraw-Hill Book Company, Inc., 1957), pp. 275-278.

TABLE V - TABULATION OF R AND LAMBDA FOR EDMONTON NEIGHBORHOODS

Neighborhood ^a	Clothing		Major Household Goods		Minor Household Goods		Hardware		Drugs and Cosmetics	
	R max	Lambda	R max	Lambda	R max	Lambda	R max	Lambda	R max	Lambda
2 ^b	undefined		0.521	<u>0.73</u>	0.469	<u>1.17</u>	0.769	<u>1.72</u>	0.453	1.08
3	0.791	<u>2.06^c</u>	0.716	<u>0.79</u>	0.817	<u>1.92</u>	0.908	<u>1.62</u>	0.542	1.29
4	0.927	<u>1.34</u>	0.927	<u>1.34</u>	0.722	<u>1.59</u>	0.706	<u>1.83</u>		III-
5	0.918	<u>2.39</u>	0.925	<u>2.43</u>	0.889	<u>1.91</u>	0.830	1.26	0.824	1.55
6	0.992	3.17	0.979	2.69	0.998	4.32		III+		III+
7	0.699	<u>1.31</u>	0.756	1.19	0.672	<u>1.60</u>	0.835	<u>0.98</u>	0.543	1.81
8	III+			III+		III+		III+		III+
9	undefined		0.220	<u>1.61</u>		undefined	undefined	undefined	undefined	undefined
10	0.975	<u>3.06</u>	0.964	<u>2.81</u>	0.981	<u>3.21</u>	0.974	<u>2.94</u>	0.949	<u>2.73</u>
11	0.989	3.72	0.931	<u>3.31</u>		III+		III+	0.990	4.03
12	III+		0.938	2.74	0.905	2.54	0.882	2.62	0.943	2.84
13	0.953	1.26		III-	0.866	<u>1.04</u>		III-	0.784	1.01
14	0.994	3.42	0.982	3.14	0.985	<u>3.62</u>	0.981	3.53		III+
15	0.812	<u>1.73</u>	0.932	<u>1.87</u>	0.966	<u>2.89</u>	0.991	<u>3.18</u>	0.984	<u>2.90</u>
16	0.936	1.76	0.850	1.33	0.900	<u>2.92</u>	0.887	<u>2.73</u>	0.874	<u>1.58</u>
17	0.887	1.41	0.896	1.44		III+		III+		III+

^aNot all neighborhoods are represented as there were too few responses in some cases for operation of the model. (See Table F - 2 of Appendix F)

TABLE V (Continued)

Neighbor- hood	Clothing		Major House- hold Goods		Minor House- hold Goods		Hardware		Drugs and Cosmetics	
	R max	Lambda	R max	Lambda	R max	Lambda	R max	Lambda	R max	Lambda
18	0.905	2.75	0.862	2.91	0.599	2.97	0.857	2.84	III+	
19	0.629	1.46	0.629	1.46	0.629	1.46	III-		III-	
21	0.753	3.01	III+		0.641	4.24	0.772	<u>3.23</u>	III+	
22	0.987	3.12	0.943	<u>1.66</u>	0.986	3.15	0.993	3.56	0.996	3.79
23	0.919	3.15	0.831	1.84	0.831	1.84	0.862	2.39	III+	
24	III+		0.907	4.05	0.907	4.05	III+		0.934	3.77
25	0.926	<u>1.31</u>	0.874	<u>1.31</u>	0.907	<u>1.63</u>	0.972	<u>2.61</u>	0.882	<u>2.52</u>
26	0.997	1.97	0.909	<u>0.82</u>	0.996	2.09	0.978	1.34	0.931	1.07
27	0.946	<u>2.10</u>	0.887	<u>1.58</u>	0.940	<u>2.33</u>	0.976	<u>3.24</u>	0.976	3.24
28	0.789	1.36	0.789	1.36	0.856	3.57	0.856	<u>3.57</u>	III+	
29	III-		III-		III-		III-		III-	
31	III-		III-		0.969	<u>1.73</u>	0.928	<u>1.43</u>	undefined	
32	0.592	<u>0.96</u>	III-		0.586	<u>1.19</u>	0.906	<u>1.28</u>	0.982	<u>2.28</u>
33	0.961	<u>1.87</u>	0.814	<u>0.93</u>	0.996	<u>2.15</u>	0.974	<u>2.30</u>	0.955	<u>1.36</u>
35	undefined		III-		III+		III+		undefined	
36	III+		III+		III+		0.709	1.23	0.709	1.23
37	III+		0.786	1.77	III+		0.878	3.24	0.835	1.71

^bRefer to F - 1 of Appendix F for location of the neighborhoods.

^cThe values of lambda for type 1 curves are underlined; those of type II are not.

remainder, the same statistic is used but the numbering is in reverse order.

The results of the tests for both clothing and major household goods λ values are shown in Table VI. It can be concluded with 99 percent confidence that the estimates are from the same population. Thus means of 2.16 and 1.88 can be calculated for clothing and major household goods respectively. These means are reasonable in that they confirm the observation that consumers are not willing to travel as far for clothing as they are for major household purchases.¹⁰

It will be remembered that when Reilly set out his law, he pointed out that the distance exponent n was a modal value and represented a distribution rather than an exact value. This was exemplified in Figure 1 of this study. Similar frequency histograms were drawn for the clothing and major household goods categories of this study and are shown in Appendix H. Modal values of 1.5 were found for both clothing and major household goods. It was then felt that if Huff's hypothesis that λ is a function of the type of shopping is true, then perhaps Wiginton's results could be included with the results of this study in a frequency histogram.

A Mann-Whitney U test was performed on Wiginton's

¹⁰Huff, Determination, p. 31.

TABLE VI

RESULTS OF STATISTICAL TESTS FOR r

Sample	k	r	$\alpha=1\%$ ^a
Clothing - upper value	23	0.228	0.505
Clothing - lower value	23	0.158	0.505
Major Household Goods			
- upper value	25	0.286	0.489
Major Household Goods			
- lower value	25	0.058	0.489

^a W. J. Dixon and F. J. Massey, Jr., Introduction to Statistical Analysis (New York: McGraw-Hill Book Company, Inc., 1957), p. 412.

Commodity A results and this study's clothing results; and on Wiginton's Commodity B results and this study's major household goods results. This test determines whether two independent groups could have been drawn from populations with similar distributions.¹¹ It was found with 99 percent confidence for both sets that this could be the case. On the basis of this test, Figures H-3 and H-4 of Appendix H were constructed which are frequency histograms of estimates of λ for clothing and major household goods respectively for both Wiginton's and this study combined. Both histograms have modal values of 1.5.

In examining the estimates of λ given by the computer program, it was felt that it could be possible that a relationship existed between λ and R, the correlation coefficient. Thus two scatter diagrams were drawn for clothing

¹¹S. Siegel, Nonparametric Statistics for the Behavioral Sciences (New York: McGraw-Hill Book Company, Inc., 1956), pp. 116-127. The Mann-Whitney U test is a nonparametric alternative to the parametric t test when the researcher wishes to avoid the t test's assumptions of a normal distribution with known mean and standard deviation. The statistic U is computed from the following:

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$$

where n_1 and n_2 are respectively the number of cases from each population and R_1 is the sum of the ranks assigned to the group whose sample size is n_1 . In the ranking process, all of the values of both samples are arranged from smallest with rank 1 to the largest with rank n_1+n_2 (with sample identity retained). The resulting U value is then tested for significance in tables given in the above reference.

and major household goods. These are shown in Figures H-5 and H-6 of Appendix H. Linear correlation coefficients for these Figures of 0.51 and 0.33 were determined. These would suggest that the model tends to de-emphasize distance as a factor as the value of λ decreased.

The other approach mentioned for analyzing the performance of the model is to study the predictions or the $E(C_{ij})$'s that were made for each neighborhood. These range from good when the correlation coefficient R approaches 1.0, to poor when R is less than 0.9. There were eleven neighborhoods which fitted into the category of having good predictions. Shown in Figure F-2 of Appendix F, these were areas 4, 6, 10, 11, 14, 16, 22, 25, 26, and 33. Upon first examination it appeared that the areas had no common characteristics or fitted no particular geographical pattern. Closer examination revealed that all the above mentioned neighborhoods either contained a shopping center or bordered upon an area containing one. What this would imply is that in these neighborhoods the decision for a consumer of where to shop is relatively simple and easily made.

Also shown in the same figure are those areas which gave the poorest predictions. Two patterns arise in this group. One is that many of them border the river which may disrupt the natural flow of consumers to shopping centers. The other pattern is of areas situated such that consumers in them may choose from two or three centers quite easily.

Consumer actions in both patterns then can be difficult to predict as a result of the consumers' insufficient information sources on where to shop. Another factor in the neighborhoods giving poor predictions is that most of them tend to be older areas and shopping patterns which developed before many of the new centers were constructed still hold.

What was noticed regarding all the predictions, either good or bad, was that they tended to give increasingly poorer fits to the actual collected data as the distance from the neighborhood to the shopping center increased. For each neighborhood the patronage attributed to the distant shopping centers was overestimated while that of the near centers was underestimated. Compared to the actual movement of consumers to distant shopping centers, the error introduced by the predictions for these centers are large, but they are not large relative to the total movement of consumers in any one neighborhood. As a result a nonparametric statistical test, such as a Kolmogorov-Smirnov Test, is not powerful enough to uncover these errors and would accept at the 90 percent significance level that each pair of predicted and actual results for a neighborhood could be from the same population.¹²

¹²Siegel, Nonparametric Statistics, pp. 127-136. This test is sensitive to differences in the distributions from which the two samples were drawn. The test is applied by making a cumulative frequency distribution for each sample of observations, using the same intervals for both distributions. For each interval, one step function is subtracted from the other and the test focuses on the largest of these observed deviations. That is

Thus this test would suggest that the predictions could be used for determining each shopping center's share of the Edmonton market.

In order then to examine more closely the predictions made by the model, it was decided to rearrange the results so they would be shown by neighborhood for each shopping center rather than by shopping center for each neighborhood. This has been done in Tables VII, VIII, and IX. The predictions are expressed in terms of the probability of the neighborhood from which any given consumer found at a shopping center originates. Except for the downtown area, only the predictions for the neighborhoods in the vicinity of shopping centers are given. This is because the errors in the predictions for outlying neighborhoods from a shopping center are large enough to render them meaningless. These erroneous predictions, which in all cases, are overestimates of the actual situation, also affect the predictions given in the above mentioned tables although relatively the errors are not that large.

$$D = \text{maximum } |S_{n_1}(X) - S_{n_2}(X)|$$

where S_{n_1} and S_{n_2} are the observed cumulative step functions.

The value of D is then tested for significance in tables given in the above reference. In this study the two groups of observation are the actual and predicted number of consumers visiting shopping centers and the intervals were the nine centers.

TABLE VII

PROBABILITY OF NEIGHBORHOOD OF ORIGINATION FOR CLOTHING
TRIPS FOR SHOPPING CENTERS

Neighborhood	Shopping Center								
	1 ^b	2	3	4	5	6	7	8	9
3 ^a	-	.015	-	.342	-	.022	.277	-	-
4	-	.017	-	.200	-	.030	.168	-	-
5	-	.037	-	-	-	.014	-	-	-
6	-	.216	-	-	-	.010	.100	-	-
7	-	.023	-	.085	-	.029	.141	-	-
10	-	.110	-	-	-	.038	-	-	.044
11	-	.075	.401	-	-	.017	-	-	.108
13	-	.009	-	-	-	.051	-	-	.017
14	-	-	.256	-	-	.019	-	-	-
15	-	-	.110	-	-	.047	-	-	.055
16	-	-	.036	-	-	.057	-	-	.104
17	-	-	-	-	-	.020	-	-	.006
18	-	-	.014	-	-	.024	-	-	-
19	-	-	.006	-	-	.018	-	-	-
21	-	-	.016	-	-	.022	-	-	-
22	-	-	-	-	-	.011	-	.191	-
23	-	-	-	-	-	.015	-	.032	-
25	-	-	-	-	-	.024	-	.082	-
26	-	-	-	-	-	.016	-	.366	-
27	.092	-	-	-	.104	.026	-	-	-
28	.061	-	-	-	.038	.016	-	.024	-
32	.233	-	-	-	.424	.052	-	-	-
33	.180	-	-	-	.209	.032	-	-	-

^a Refer to Figure F-1 of Appendix F for location of the neighborhoods.

^b The centers in order from 1 to 9 are Bonnie Doon, Westmount, Northgate, Meadowlark Park, Capilano Mall, Downtown Edmonton, Centennial Village, Southgate and Park Plaza.

TABLE VIII

PROBABILITY OF NEIGHBORHOOD OF ORIGINATION FOR MAJOR
HOUSEHOLD GOODS TRIPS FOR SHOPPING CENTERS

Neighbor- hood	Shopping Center								
	^b 1	2	3	4	5	6	7	8	9
2 ^a	-	.018	-	.081	-	.022	.150	-	-
3	-	.024	-	.216	-	.035	.128	-	-
4	-	-	-	.328	-	.022	.130	-	-
5	-	.050	-	-	-	.014	-	-	-
6	-	.178	-	.048	-	.012	.101	-	-
7	-	.018	-	.114	-	.019	.063	-	-
9	-	.011	-	.091	-	.011	-	-	-
10	-	.102	-	-	-	.032	-	-	.043
11	-	.061	.357	-	-	.022	-	-	.092
12	-	.026	.012	-	-	.047	-	-	.073
14	-	-	.268	-	-	.017	-	-	.048
15	-	-	.140	-	-	.033	-	-	.049
16	-	-	.034	-	-	.037	-	-	.067
17	-	-	.007	-	-	.015	-	-	.005
18	-	-	.013	-	-	.014	-	-	-
19	-	-	-	-	-	.014	-	-	-
22	-	-	-	-	-	.015	-	.152	-
23	-	-	-	-	-	.011	-	.038	-
24	-	-	-	-	-	.019	-	.050	-
25	-	-	-	-	-	.070	-	.134	-
26	-	-	-	-	-	.034	-	.291	-
27	.108	-	-	-	.118	.018	-	-	-
28	.043	-	-	-	-	.012	-	-	-
33	.225	-	-	-	.271	.035	-	-	-
37	.072	-	-	-	-	.026	-	-	-

^aRefer to Figure F-1 of Appendix F for location of the neighborhoods.

^bThe centers in order from 1 to 9 are Bonnie Doon, Westmount, Northgate, Meadowlark Park, Capilano Mall, Downtown Edmonton, Centennial Village, Southgate, and Park Plaza.

TABLE IX

PROBABILITY OF NEIGHBORHOOD OF ORIGINATION FOR MINOR HOUSE-
HOLD GOODS TRIPS FOR SHOPPING CENTERS

Neighborhood	Shopping Center								
	1 ^b	2	3	4	5	6	7	8	9
2 ^a	-	.022	-	.069	-	.029	.164	-	-
3	-	.021	-	.334	-	.038	.192	-	-
4	-	-	-	.283	-	.033	.097	-	-
5	-	.040	-	-	-	.024	-	-	-
6	-	.287	-	-	-	.010	.027	-	-
7	-	.027	-	.116	-	.035	.077	-	-
10	-	.131	-	-	-	.047	-	-	.043
12	-	.034	.012	-	-	.088	-	-	.083
13	-	.010	-	-	-	.053	-	-	-
14	-	-	.268	-	-	.022	-	-	.048
15	-	-	.171	-	-	.031	-	-	.040
16	-	-	.042	-	-	.068	-	-	.189
18	-	-	.014	-	-	.030	-	-	-
19	-	-	.006	-	-	.023	-	-	-
21	-	-	.017	-	-	.025	-	-	-
22	-	-	-	-	-	.012	-	.171	-
23	-	-	-	-	-	.020	-	.026	-
24	-	-	-	-	-	.033	-	.035	-
25	-	-	-	-	-	.031	-	.107	-
26	-	-	-	-	-	.018	-	.401	-
27	.085	-	-	-	-	.027	-	-	-
28	.055	-	-	-	-	.014	-	-	-
31	.053	-	-	-	.440	.053	-	-	-
32	.074	-	-	-	.377	.062	-	-	-
33	.222	-	-	-	.147	.035	-	-	-

^aRefer to Figure F-1 of Appendix F for location of the neighborhoods.

^bThe centers in order from 1 to 9 are Bonnie Doon, Westmount, Northgate, Meadowlark Park, Capilano Mall, Downtown Edmonton, Centennial Village, Southgate and Park Plaza.

A possible explanation of why the model distorts the market share for a shopping center as the distance from it increases may lie in such things as road patterns, the North Saskatchewan River running through the city, the imperfect knowledge the consumer has of distant centers, and the weather.¹³ It may be that the adverse effects of distance could be corrected in the model by having the travel time exponent increasing in a nonlinear fashion as the distance to a shopping center for a consumer increases rather than it remaining stationary as it does now.

A number of points can be seen by examining the predictions in Tables VII, VIII, and IX. One is that Edmonton consumers tend for the most part to patronize those centers nearest to them. This can be an interesting point to promotional people who are attempting to reach the majority of their customers at a minimum of cost. As an example of how these tables can be used, the case of clothing trips to Bonnie Doon can be examined. It can be seen that these merchants obtain 18 percent of their business from neighborhood 33, 23.3 percent from neighborhood 32, and 9.2 percent from neighborhood 27. Probably these merchants have a good hold on the clothing markets in neighborhoods 32 and 33, but are competing more closely with other centers in the other sur-

¹³The data for the model was collected in the middle of winter when roads in the city can be treacherous and can affect a consumer's propensity to travel.

rounding neighborhoods. In neighborhood 31 they would be competing with Capilano and in neighborhoods 28 and 29 with Southgate, and in these areas may wish to increase their promotions to attempt to get a larger market share. Also as an example of the information available from the tables, a comparison between Bonnie Doon and Capilano can be made which would indicate Bonnie Doon's area of attraction is wider spread than that of Capilano which consists almost entirely of neighborhoods 31 and 32.

A second point is the rather even drawing power of the city center. With its wide range of goods and services it attracts from all over the city. Another point is that no center draws very heavily from the neighborhoods in the east end of the city north of the river. A shopping center is presently planned for this area and, as its population grows, it should prove to be a good location.

It is obvious that Huff's two proxy variables of travel time and size of shopping facility are not adequate to explain the Edmonton situation fully. It was thought that income level might have a significant effect on the predictive ability of the model and in order to check this idea, the respondents were divided at the \$9000 level into high and low income groups and each was run through the model. The predictions which resulted from these runs were not any different from, or provided any improvement on those given in Tables VII, VIII, and IX. Other variables

which could be examined in the model in an attempt to improve its predictive ability are geographical factors, socio-economic factors, demographic factors, and modes of transportation. It is unfortunate that the data which would be required for testing these variables was not collected in the original survey.

Summary

The previous section has shown the Huff's model of consumer spatial behavior is able only to a limited extent to predict consumer movements in the Edmonton area. From the breaks in the results such as where the R and values were not given by the model and from the errors present in the predictions, it would seem that the model does not include all the relevant variables that it should. Chapter VI will suggest some avenues of research for correcting these deficiencies.

CHAPTER V

AN ANALYSIS OF CONSUMER SPATIAL BEHAVIOR IN EDMONTON

An Examination of the Data

The questionnaire used to gather the data relevant to the operation of the model also generated a considerable amount of other data regarding consumer spatial behavior in Edmonton. As this information may prove to be of interest to the reader, this chapter will present what the respondents have or have not reported and attempt to offer some explanations for their actions.

To begin with, over half of the questionnaires were never returned. Due to the fact that the respondents were selected at random and that those who responded are anonymous, it is not possible to identify the non-respondents and to determine if they have any common characteristics. What can be done, is to look at those neighborhoods which had the highest and lowest return rates and attempt to determine from the respondents that did reply, whether common characteristics exist. In the low returns category, two groups emerge. One group consists of neighborhoods 20 and 34 which are on the outskirts of the city and are very

sparsely populated, containing only 504 people.¹ The other group consists of neighborhoods 17, 19, 24, and 28. The respondents of these areas tend to have lower incomes and a lower education level than the overall sample. These areas are also older sections of the city.

In the higher response category, another two groups emerge. One consists of neighborhoods 36 and 37 which are satellite communities outside the city limits. It is felt their high response rates were due to the fact they have a greater interest in the study than do other people. Neither neighborhood has its own major shopping area and for these people a shopping trip into the city is more of an occasion than it is for city dwellers. The other group consists of neighborhoods 4, 6, 7, 8, 22, and 23. It was found that these areas had in common, a higher income and educational level than the total sample. Professional and managerial positions are the most common occupations in these neighborhoods.

As well as the nonreturns and the replies, there were also 11.2 percent undeliverable questionnaires. This is higher than would normally be expected and this is attributable to the fact that the census lists, while being the most up to date, were just over a year old. When the

¹Refer to Figure F - 1 of Appendix F for location of neighborhoods.

undeliverables were examined it was found that the majority of them were from apartment dwellers in the higher density areas of the city. This group of people are noted for their higher rate of mobility. The undeliverables would then indicate that apartment dwellers are under-represented in the survey.

From the above it can be seen that the sample is biased towards homeowners, and towards higher income and higher educated people.

Income and Shopping Center Choice

Because of budget considerations, lower income people may be expected to shop where prices appear to be the lowest or where there is a greater variety of goods in order that they may shop around for the best bargain. If this is the case then these income groups will rank price and variety as more important factors influencing shopping center choice than will higher income groups. It was found, as is shown in Table X, that lower income groups do rank price as a relatively more important factor, but do not rank variety any differently than do other groups.

It was also found that when price was an important consideration and the respondent was in the low income categories, he had more tendency to choose Capilano Mall and Centennial Village. These two centers contain stores which

TABLE X

RANKING OF THE FACTORS INFLUENCING SHOPPING
CENTER CHOICE FOR LOW AND HIGH INCOME GROUPS

Factor Influencing Shopping Center Choice	Rank by Low Income	Rank by High Income	Overall Rank
Convenience	1	1	1
Price	2	6	4
Quality	3	2	3
Habit and Familiarity	4	3	2
Variety	5	5	5
Service	6	4	6
Advertising	7	7	7

are perceived by consumers to have lower prices. The other center used extensively by lower income groups is the downtown area. This is a result of the fact that 31.2 percent of this group use the bus system for their transportation and the downtown area is the focal point of this system.

The centers which appeal to the high income group for clothing and major goods are, in order of patronage, the downtown area, Westmount, and Southgate. Westmount and Southgate are close to the high income neighborhoods and contain stores which cater to consumers on grounds of quality, service and status.

Table XI gives the percent patronage for all shopping centers for the entire sample.

TABLE XI
PERCENT PATRONAGE OF
CENTERS FOR ALL CLASSES OF GOODS

Shopping Centre	Clothing	Major Household Goods	Minor Household Goods	Hardware	Durges & Cosmetics
1 ^a	11.5	5.9	10.3	6.5	5.0
2	15.9	15.3	16.2	13.1	13.7
3	11.5	10.9	12.5	12.1	10.6
4	5.9	3.4	5.0	3.7	2.8
5	2.8	1.2	3.7	4.0	4.0
6	31.2	43.0	24.6	24.0	21.5
7	1.6	1.6	4.4	4.0	3.1
8	10.9	7.5	10.9	7.8	7.5
9	5.3	5.9	5.3	4.7	1.6
Other	3.4	5.3	7.2	19.9	30.2

^aThe shopping centers are as follows:

1. Bonnie Doon
2. Westmount
3. Northgate
4. Meadowlark Park
5. Capilano Mall
6. Downtown Edmonton
7. Centennial Village
8. Southgate
9. Park Plaza

Factors Influencing Shopping Center Choice

A crosstabulation was performed between the shopping center chosen by a consumer and those factors which he said influenced his decision to shop there. This was done to see if any center presented an image to the public.

Westmount, Northgate, and Southgate were perceived to have the highest prices while Centennial Village had the lowest prices. Service and quality were said to be characteristic of Westmount, Northgate, Meadowlark Park, Downtown Edmonton, and Southgate while Capilano Mall and Centennial Village were ranked the lowest in terms of service. This last point is due to the fact that the major stores in these centers are of a self-serve type. Variety was felt to be the highest at Meadowlark Park, Southgate, and the downtown. While all centers were felt to be convenient, the downtown area was criticized somewhat for its lack of adequate parking and for the fact that it is not entirely enclosed. Meadowlark Park does a large amount of advertising for the entire center and this showed up in the survey. A large percentage of the users of this center stated that they were attracted by advertising.

One interesting point is the image of fairness and integrity that Woodward Stores has developed among its customers. Many of its customers took the effort to write in that they shopped at Woodward Stores because of these reasons. No other respondents mentioned this of any other store.

Information Sources

Table G - 2 of Appendix G shows the responses for the question concerning where consumers get their information on goods they are shopping for. From this it can be seen that the respondents perceive the written word in the form of the daily paper, store flyers, and catalogues to be of the most importance. Second to these was the actual physical comparison of goods among stores. It would be thought that those people who compare merchandise among stores would tend to visit more than one shopping center on a shopping trip. This was found to be so.

Crosstabulations were performed on the information sources with education and income to see if any patterns emerged. None were found.

Income, Education, and the Working Family

As would be expected there is a close relationship between income and education among the respondents. The higher the education, generally the higher the income level. While this was found to be true in the aggregate, there were a large number of individual cases where this was not true. The explanation for this lies in the fact that in many households, 39 percent to be exact, there is more than one wage-earner. The implication of this is that difficulties are raised if only income is used as a predictive tool for

social status. Families earning incomes which are above that of their social class cannot always be expected to spend their money on the same items or in the same places as that class to which their income is equal.

Spatial Movements

This section examines the actual physical movements of Edmonton shoppers beginning with modes of transportation used. 15.3 percent of the respondents used the bus system as their method of movement. Bus usage was more popular in lower income groups with 31.2 percent of this group. The low usage was in the high income groups with 8.4 percent. For reasons previously mentioned, bus patrons tend to shop in the downtown area. These trips are normally made alone during weekdays. Only 8 percent of these trips were made with other members of the family. As taxis were used only 1.5 percent of the sample, not enough results were obtained to draw any inferences. The remainder of the respondents, 83.2 percent, used the automobile as their form of transportation. Pedestrian traffic was considered to be of such minor importance, it was not included in the study.

Only one quarter of shopping trips made included children in the shopping. The remainder were either made alone or with the spouse. Trips were made fairly evenly among weekdays, evenings, and weekends. Trips are 36, 29 and 35 percent respectively.

Table G - 3 of Appendix G shows the tabulations of the answers for the number of shopping centers visited in a shopping trip. It can be seen that shoppers by and large, only go to one shopping center during a shopping trip.

Summary

The least the preceding sections have done is to show that no one representative shopper can be constructed for the Edmonton area. Instead there are a number of groups with their dividing lines set in both socioeconomic and geographical variables. It has been a fault of traditional gravitation models that they have estimated solutions to each shopper's problem in an identical fashion. No corrections are made for varying socioeconomic factors or for the factors attracting consumers to shopping centers other than the size of the center.

The next chapter summarizes the findings of this study, offers some ideas for improving Huff's model, and suggests direction for further research.

CHAPTER VI

CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY

A Restatement of the Purpose of the Study

In the Introduction it was stated that the purpose of this study was to see whether a model formulated and tested elsewhere could be used in the Edmonton area to determine retail trade areas. From the previous chapter it can be said that the model, while seemingly able to give partial results, is deficient in some aspects and requires corrective action.

A Recapitulation of the Three Studies

Chapter III described a probabilistic model of consumer spatial behavior developed by Huff which could be used to predict consumer movements. His empirical test of the model in the Los Angeles Metropolitan Area was also presented. Huff's general comments from this test were that the model appeared to give good predictive results although it required further testing.

This was done in the study in the Vancouver, B. C. area by Wiginton. Wiginton found that the model was not able to give valid results for this area. The differing

results given by the two studies was the cause for the initiation of the present study.

Wiginton's results suggested a basis for rejection of the model not found in this study. This could have resulted from his methodology. As was previously mentioned, Wiginton's questionnaire differed from the style used by Huff. He perhaps did not include all the shopping areas that were relevant such as New Westminster, and the downtown area was handled in a method which is not considered correct here. A significant point not mentioned by Wiginton is whether public transportation was handled in his study. Vancouver enjoys a good public transportation system to and from the downtown area and this could affect his results. In this study those using public transportation were disqualified from the model. Although over 15 percent of the respondents did use public transportation, they were too few and scattered to be run in the model as a separate group.

If the model is deficient, then why did Huff obtain encouraging results in his pilot test? It can be said that his results only appeared encouraging because he had overlooked a number of points. One is that he had not properly analyzed the estimates he had obtained. Perhaps if Huff had performed a sensitivity analysis similar to the plotting function used in this and Wiginton's studies, he would have realized the model's shortcoming in not estimating really unique λ values.

A second point concerns the correlation coefficient of Equation III - 5.¹ Here it seems Huff did not realize that R^2 could be negative and its resulting implication that the model is not able to fit actual behavior as well as purely random behavior.

Another criticism of Huff's study is the rather unique physical setting of the test area. The area concerned does not have a central downtown core and the three neighborhoods that were tested are grouped about one shopping center. The proximity of this center to the test neighborhoods made it such that the spatial behavior could be quite easily predictable. Inclusion of a downtown area and other more competitive centers, as was done in this study and Wiginton's, puts the model to a more rigorous test. Jonassen has shown that consumer attitudes do differ between shopping centers and the downtown core.²

This study then went further than the two previous ones and in Chapter V examined many of the variables affecting spatial behavior in Edmonton. The findings of the chapter were that predictive models of intra-urban retail trade areas must take into account variables other than

¹This is not a normal correlation coefficient but rather the one devised by Huff and given in Equation III - 5.

²C. T. Jonassen, The Shopping Center Versus Downtown (Columbus, Ohio: Bureau of Business Research, College of Commerce and Administration, The Ohio State University, 1955).

retail selling area and travel time.

Suggestions for Further Study

This paper has shown that Huff's model, while able to give partial results, is not entirely complete. It is suggested here that this fault can probably be corrected by the recognition in the model of some of the variables which affect consumer shopping patterns other than the size of the shopping area and travel time. While further study is required into the effects of the various variables, it is felt the answer to the missing variables lies in the areas of socioeconomic factors, demographic factors, and product factors.

For example, this writers feels that income should play an important part in the model. Converse's studies have indicated that higher and lower income consumers do not behave alike. This study found the opposite result in the Edmonton situation but this does not disprove Converse's results. Rather it is felt that his results are essentially correct. This difference possibly occurs from the fact that in this study, only the family's total present income was used or that the wrong dividing point on income was decided upon. Income used as a variable in this manner does not take into account the number of workers in the family, their life style, or their social status in the community. Both studies would probably benefit by using variables other than

income. One approach could be to use a two dimensional matrix with a progression of occupational situations (unemployed, blue collar, white collar, manager, and executive) along one side and a progression of family life cycle along the other (single; young marrieds, no children; young marrieds, children; older marrieds, older children; senior citizens). Such a classification would give a number of groups each having common characteristics.

Other factors affecting a consumer's decision about where he will shop are such things as the type of product he is looking for, and how he perceives the images of the stores available to him.

Consideration of a number of these variables is then going to mean that all consumers can not be grouped together in a model as traditional gravitation models have done. Instead a number of categories will have to be formed which will be dealt with separately as was attempted with income in this study. In conjunction with these variables, considerable experimentation will be required to determine exponent values.

This study has shown that Huff's probabilistic model of consumer spatial behavior is to some extent inadequate but is possibly repairable. New direction has been offered for this line of action.

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BIBLIOGRAPHY

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APPENDICES

APPENDIX A

HUFF'S CONSUMER BEHAVIOR QUESTIONNAIRE

•

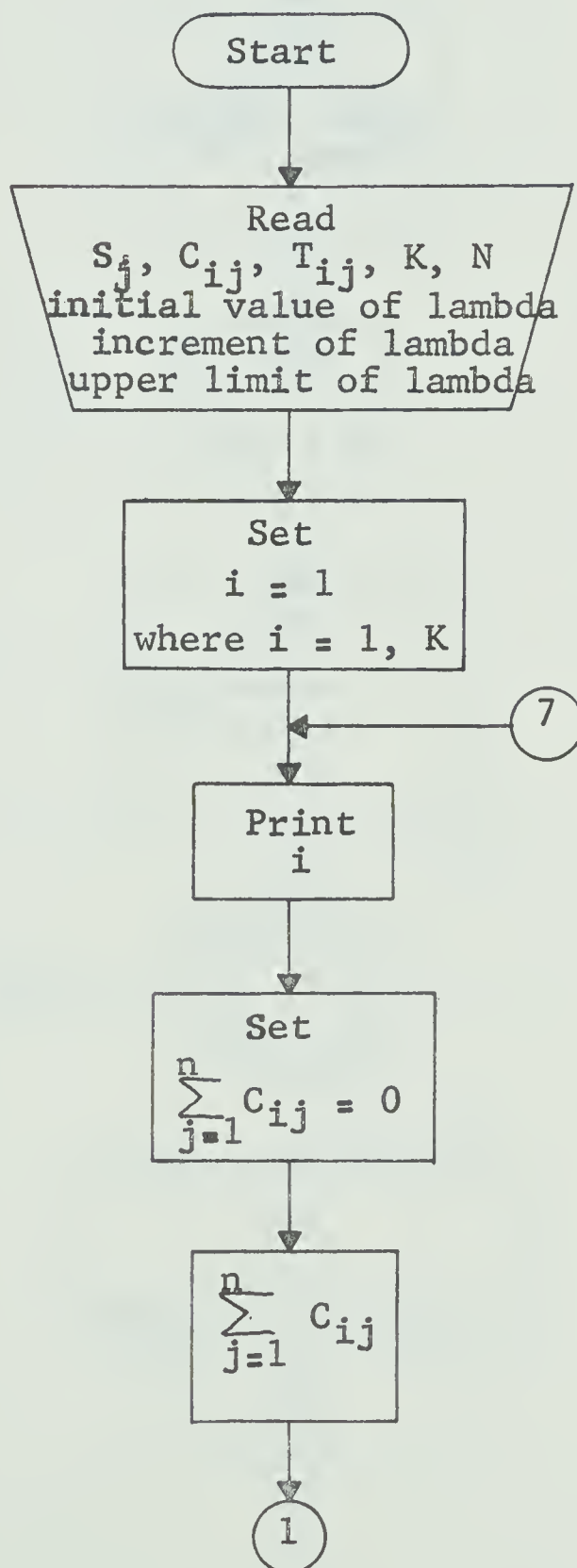
1. At what SHOPPING CENTER did you LAST make a purchase of the following items?
- | | |
|----------------------------|-------------------------------|
| Clothing..... | Household
Furnishings..... |
| Food..... | Hardware..... |
| Cosmetics or
Drugs..... | |
2. How many members of your household normally work in excess of four hours per day?.....
3. What type of WORK does the major income earner of your household do?
.....Self Employed? YES () NO ()
4. What are the APPROXIMATE AGES of those persons living with-in your household?
MALE (...)(...)(...)(...) FEMALE (...)(...)(...)(...)
5. How many CARS in the family?.....
6. At what shopping center do you NORMALLY MAKE THE MAJORITY of the following family purchases?
- | | |
|----------------------------|-------------------------------|
| Clothing..... | Household
Furnishings..... |
| Food..... | Hardware..... |
| Cosmetics or
Drugs..... | |
7. What bracket as indicated below most closely fits your total FAMILY INCOME?
- | | |
|----------------------|------------------|
| \$ 0-1999..... | \$5000-5999..... |
| 2000-3999..... | 6000-7999..... |
| 4000-4999..... | 8000-9999..... |
| \$10,000 & over..... | |

APPENDIX B

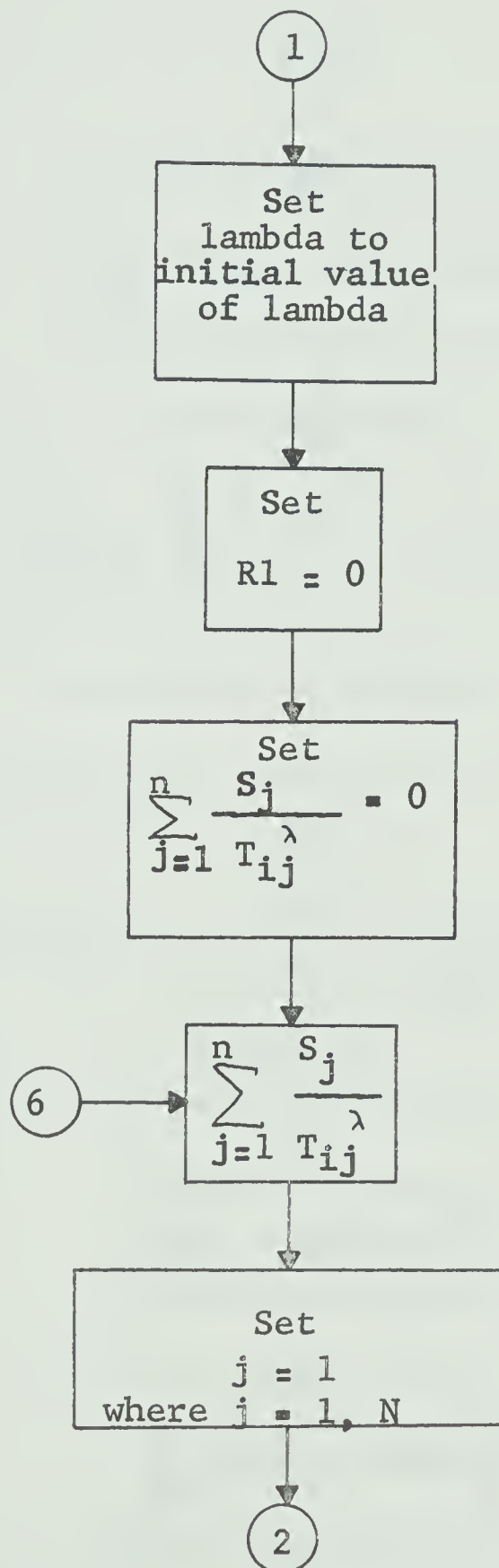
FLOW DIAGRAM FOR COMPUTER PROGRAM

APPENDIX B

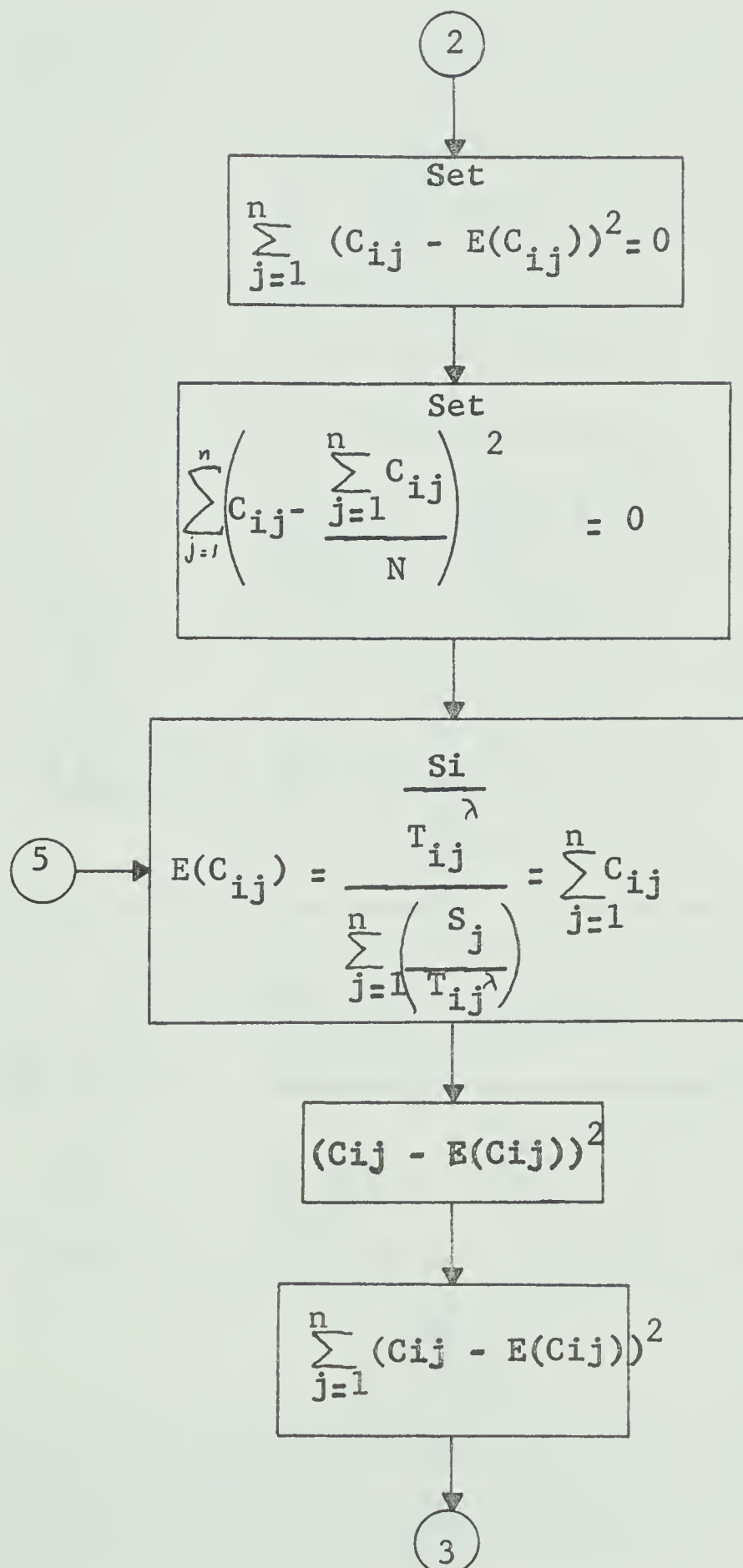
FLOW CHART FOR SUCCESSIVE APPROXIMATION OF LAMBDA



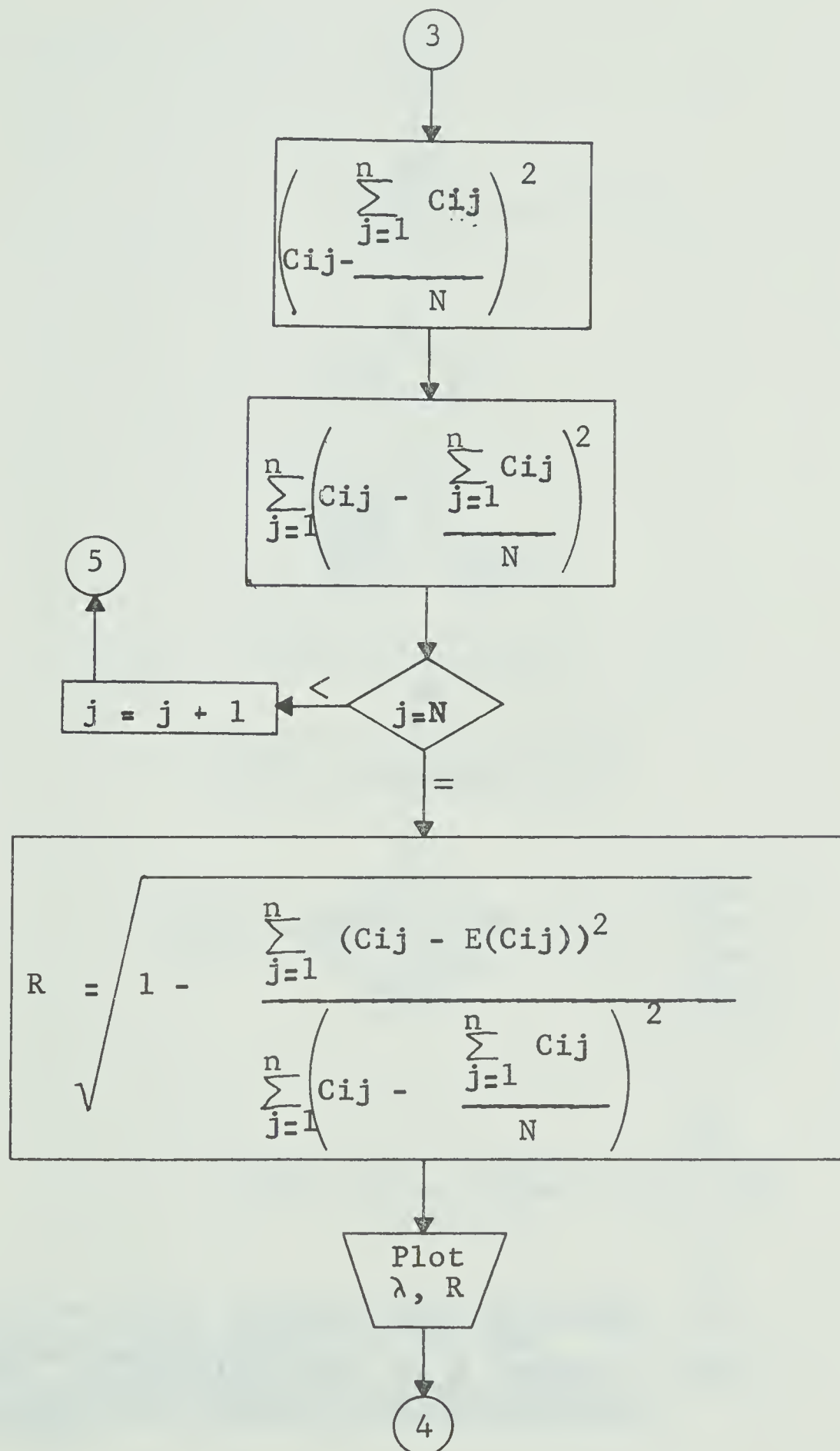
APPENDIX B (Continued)



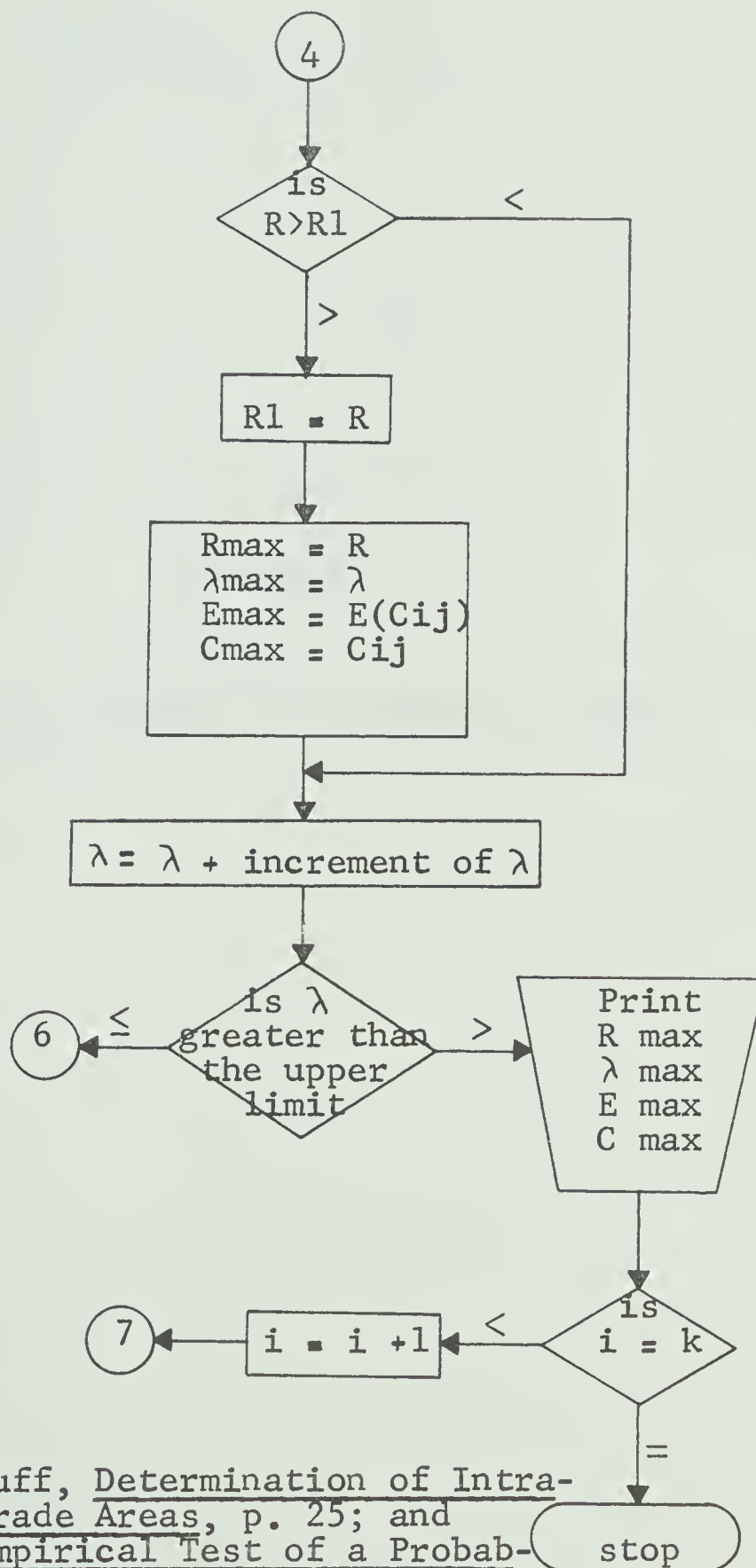
APPENDIX B (Continued)



APPENDIX B (Continued)



APPENDIX B (Continued)



Adapted from Huff, Determination of Intra-Urban Retail Trade Areas, p. 25; and Wiginton, An Empirical Test of a Probabilistic Model of Consumer Spatial Behavior, p. 163-166.

APPENDIX C

COMPUTER PROGRAM FOR ESTIMATING LAMBDA

APPENDIX C

COMPUTER PROGRAM FOR ESTIMATING LAMBDA

```

0001    DIMENSION BUFF(1024)
0002    DIMENSION S(9),C(35.9),T(35.9),EC(35.9),XEC1(35)
0003    CALL PLOTS (BUFF,4096)
0004    READ (5,1) K,N
0005    1 FORMAT (214)
0006    READ (5,2) (S(J),J=1,N)
0007    2 FORMAT (9F8.0)
0008    READ (5,3) ((C(I,J),J=1,N),I=1,K)
0009    3 FORMAT (9F2.0)
0010    READ (5,4) ((T(I,J),J=1,N),I=1,K)
0011    4 FORMAT (6X, 9F3.0)
0012    READ (5,5) ALMDA,DLMDA,BLMDA
0013    5 FORMAT (3F6.3)
0014    6 FORMAT (10X, 15H SAMPLE AREA NO 12)
0015    20 FORMAT (/6X,F10.5,4X,F6.3/(4X,F6.2,4X,F6.2,4X,F6.2)/)
0016    DO 99 I=1,K
0017    WRITE (6,6) I
0018    CALL AXIS (0.0,0.0,1HR,+1.20.0,90.0,0.1,0.1,10.0)
0019    CALL AXIS (0.0,0.0,6HLAMBDA,-6,9.0,0.0,0.5,0.5,10.0)
0020    SMC=0
0021    DO 7 J=1,N
0022    SMC=SMC+C(I,J)
0023    7 CONTINUE
0024    CLMDA=ALMDA
0025    R1=0
0026    IPEN=3
0027    18 SMST=0
0028    DO 8 j+1,N
0029    SMST=SMST+S(J)/T(L,J)**CLMDA
0030    8 CONTINUE
0031    XN=N
0032    SMCEC=0
0033    SMCCN=0
0034    DO 10 J=1,N
0035    EC(I,J)=(S(J)/T(I,J)**CLMDA)*SMC/SMST
0036    CEC=(C(I,J)-EC(I,J))**2
0037    SMCED=SMCEC+CEC
0038    CCN=(C(*,J)-SMC.XN)**2
0039    SMCCN=SMCCN+CCN
0040    10 CONTINUE
0041    SP=1.-SMCEC/SMCCN
0042    IF (SR) 11,12,12
0043    11 CALL SRNEG(CLMDA)
0044    GO TO 13
0045    12 R=SR(SR)

```


APPENDIX C (Continued)

```

0046      CALL PLOT (2.*CLMDA-1..10.*R,IPEN)
0047      IF(R-R1)15,16,16
0048 15 CLMDA=CLMDA+DLMDA
0049 13 IPEN=2
0050      IF(BLMDA-CLMDA)17,18,18
0051 16 R1=R
0052      RMAX=R1
0053      CLMDA=CLMDA
0054      DC 19 J=1,N
0055      XEC1(J)=EC(1,J)
0056 19 CONTINUE
0057      GO TO 15
0058 17 WRITE (6,20) RMAX,ELMDA,(XEC1(J),C(1,J),T(1,J),J=1,N)
0059      CALL SYMBOL (2.*ELMDA-2.,10.*RMAX,0.21,4.0.,-1)
0060      CALL PLOT (11.,0.,-3)
0061 99 CONTINUE
0062      CALL PLOT (8.0,0.0,999)
0063      STOP
0064      END

```

```

0001      SLBROUTINE SRNEG(CLMDA)
0002      WRITE (6,50) CLMDA
0003 50 FORMAT (.6X,32H SR IS UNDEFINED AT LAMBDA EQUAL F6.3)
0004      CLMDA=CLMDA+0.5
0005      RETURN
0006      END

```


APPENDIX D

COVERING LETTER FOR EDMONTON STUDY

APPENDIX D

COVERING LETTER FOR EDMONTON STUDY



FACULTY OF BUSINESS ADMINISTRATION AND COMMERCE

THE UNIVERSITY OF ALBERTA
EDMONTON 7, CANADA

January 5, 1971

Dear Sir or Madam:

I am a graduate student at the University of Alberta carrying out a study of shopping centers in the Edmonton area which may lead to improved facilities, services, and selections for you in the future. To this end, information is required from as many consumers as possible concerning their shopping habits.

This study is being carried out by me as part of a thesis leading to a Master's Degree in Business Administration at the University of Alberta. If there is any question regarding the validity or intended use of this study, please have no hesitation in checking with me at 432-5778 or my supervisor, Professor M.J. Dunn, at 432-5828 during the daytime.

Since you represent one of the selected sample households, your cooperation in answering a few questions listed on the enclosed questionnaire would be most appreciated. A self-addressed envelope has been enclosed for your convenience in returning the questionnaire. It is requested that in order for your replies to be used in the study, your questionnaire be returned no later than January 25. Since no form of identification is required on the questionnaire, your responses will be completely anonymous.

May I thank you in advance for your cooperation in assisting me in this endeavor.

Sincerely yours,

D.J. McCune

DJM:lr

APPENDIX E

CONSUMER BEHAVIOR QUESTIONNAIRE FOR EDMONTON STUDY

APPENDIX E

CONSUMER BEHAVIOR QUESTIONNAIRE FOR EDMONTON STUDY

1. At what SHOPPING CENTER did you LAST make a purchase of the following items?
(For your convenience a list of some centers is given at the bottom of the page. If the one you want is not there, please write it in.)

- (a) CLOTHING _____
- (b) MAJOR HOUSEHOLD GOODS _____
(such as furniture, TV, rugs,
fridge, and stereo)
- (c) MINOR HOUSEHOLD GOODS _____
(such as kitchen utensils,
towels, lamps, and ornaments)
- (d) HARDWARE _____
(such as tools and paint)
- (e) DRUGS AND COSMETICS _____

2. At what SHOPPING CENTER do you NORMALLY MAKE THE MAJORITY of the following family purchases?

- (a) CLOTHING _____
- (b) MAJOR HOUSEHOLD GOODS _____
- (c) MINOR HOUSEHOLD GOODS _____
- (d) HARDWARE _____
- (e) DRUGS AND COSMETICS _____

3. In shopping for the above items, what FACTORS INFLUENCE your selection of a shopping center? (Please check ✓)

- (a) Convenience _____
- (b) Price _____
- (c) Service _____
- (d) Product quality _____
- (e) Product variety _____
- (f) Habit and familiarity _____
- (g) Advertising _____
- (h) Other (Please specify) _____

4. You can get a lot of information about goods you are shopping for from the various SOURCES below. Please check (✓) those you find helpful to yourself and double check (✓ ✓) the one you consider the most important.

- (a) The Edmonton Journal _____
- (b) Other community papers _____
- (c) TV _____
- (d) Leaflets delivered to your door _____
- (e) Radio _____
- (f) Catalogues _____
- (g) Your friends _____
- (h) By going from store to store
comparing merchandise _____
- (i) Other (Please specify) _____

-
- | | | |
|-----------------|-----------------------|------------------------|
| (a) Bonnie Doon | (d) Meadowlark Park | (g) Centennial Village |
| (b) Westmount | (e) Capilano Mall | (h) Southgate |
| (c) Northgate | (f) Downtown Edmonton | (i) Park Plaza |

APPENDIX E (Continued)

5. On a shopping trip, which of the following do you NORMALLY do? (Please check)

- | | |
|-----------------------------|----------------------------------|
| (a) Shop alone _____ | (h) Shop weekends _____ |
| (b) Take the children _____ | (i) Only visit one center _____ |
| (c) Take the bus _____ | (j) Sometimes visit more _____ |
| (d) Take a taxi _____ | than one center _____ |
| (e) Take a car _____ | (k) Often visit more than _____ |
| (f) Shop weekdays _____ | one center _____ |
| (g) Shop evenings _____ | (l) Always visit more than _____ |
| | one center _____ |

6. How many members of your household NORMALLY WORK in excess of FOUR hours per day? (Please check)

- | | |
|----------------|-------------------------|
| (a) None _____ | (c) Two _____ |
| (b) One _____ | (d) More than two _____ |

7. What type of WORK does the major income earner of your household do? (Please check)

- | | |
|------------------------------------|---------------------------|
| (a) Managerial, professional _____ | (d) Clerical, sales _____ |
| (b) Service, transportation, _____ | (e) Manufacturing _____ |
| communication _____ | (f) Labourers _____ |
| (c) Craftsmen, tradesmen _____ | (g) Other _____ |

8. In your household, how many people are there in the following AGE categories?

- | | |
|-------------------|-------------------|
| (a) 1 - 10 _____ | (d) 36 - 50 _____ |
| (b) 11 - 20 _____ | (e) 51 - 65 _____ |
| (c) 21 - 35 _____ | (f) over 65 _____ |

9. What is the highest level of EDUCATION reached by the head of the household? (Please circle)

1 2 3 4 5 6 7 8 9 10 11 12 Bachelors Masters Ph.D.

10. Home ownership. (Please check)

- | | |
|--------------------------|-----------------------------|
| (a) Own your house _____ | (c) Rent an apartment _____ |
| (b) Rent a house _____ | |

11. What range as indicated below most closely fits your total family INCOME? (Please check)

- | | |
|---------------------------|----------------------------|
| (a) \$ 0 - \$3000 _____ | (d) \$9000 - \$12000 _____ |
| (b) \$3000 - \$6000 _____ | (e) over \$12000 _____ |
| (c) \$6000 - \$9000 _____ | |

12. The person filling out this questionnaire is (Please check)

- | | |
|------------------------|----------------------|
| (a) Female adult _____ | (b) Male adult _____ |
|------------------------|----------------------|

APPENDIX F

SAMPLE SURVEY DATA

FIGURE F - 1

GEOGRAPHICAL RELATIONSHIP OF THE
SELECTED SHOPPING CENTERS TO THE SAMPLE NEIGHBORHOOD

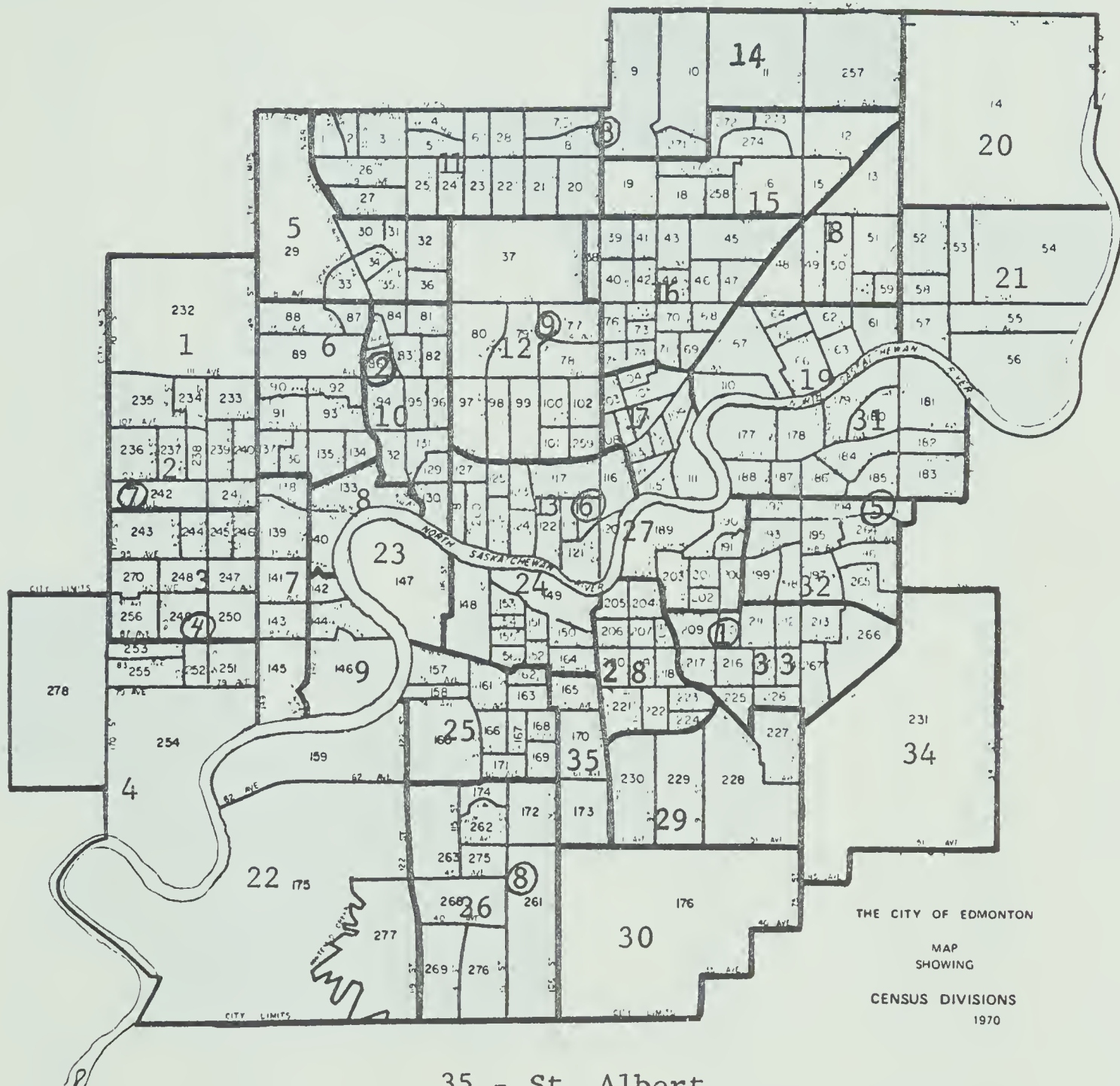


FIGURE F - 2

GEOGRAPHICAL RELATIONSHIP OF WELL AND
POORLY PREDICTED NEIGHBORHOODS

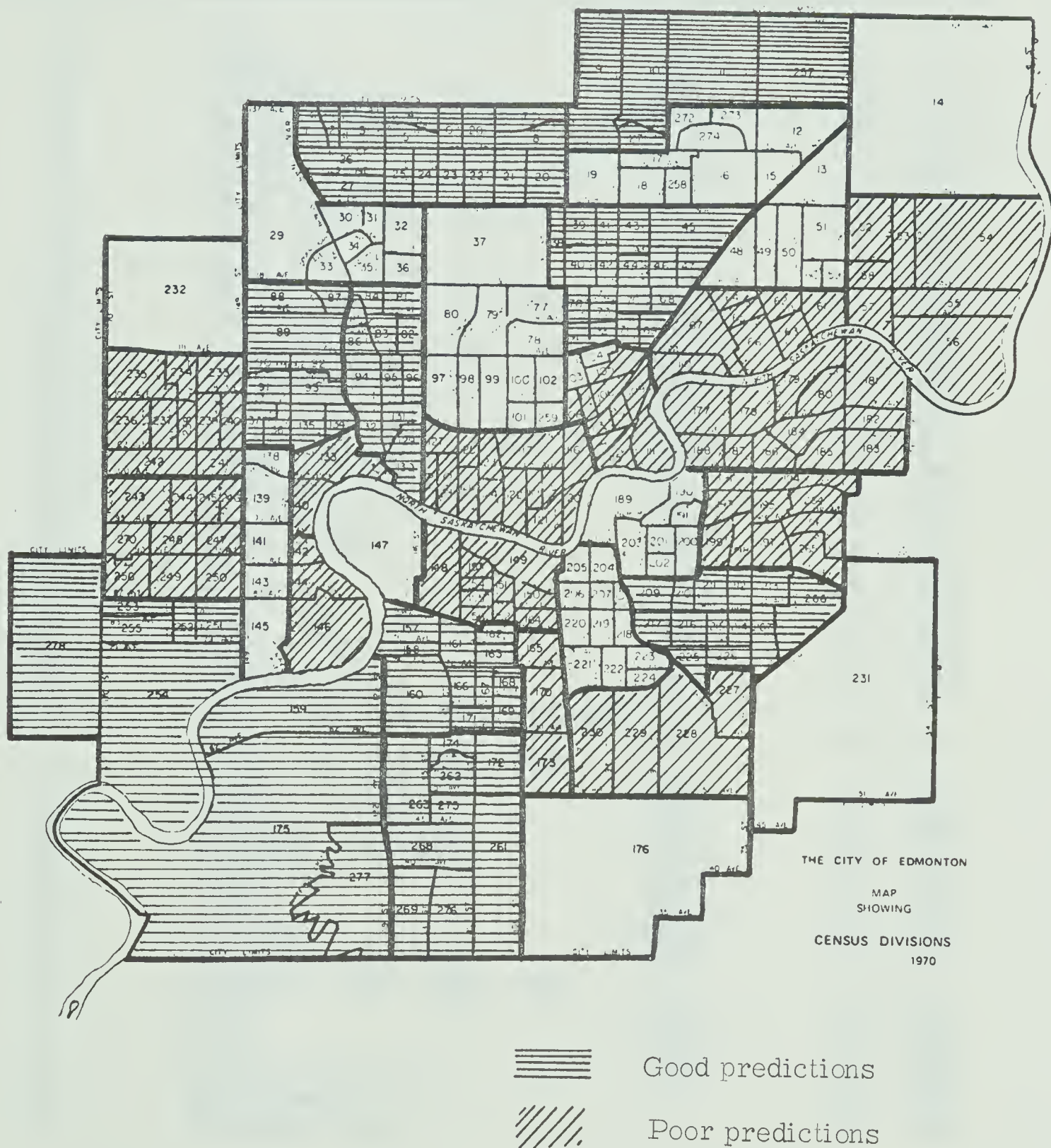


TABLE F - 1

SAMPLE STRATA CHARACTERISTICS

Neighborhood	Civic Polls #	Population	Sample	Σ
1	232	535	2	2
2	233-242	15597	32	34
3	243-250, 256, 270	18866	38	72
4	251-255, 278	11195	20	92
5	29-36	10296	21	113
6	87-93, 134-137	12684	26	139
7	138, 139, 141, 143, 145	8738	18	157
8	133, 140	2136	5	162
9	142, 144, 146	3730	8	170
10	81-86, 94-96, 129-132	17179	35	205
11	1-8, 20-28	28040	57	262
12	37, 77-80, 97-102, 259	18372	37	299
13	116-128, 260	17365	36	335
14	9-11, 257, 271	16226	33	368
15	12, 15-19, 258, 272-274	22547	46	414
16	39-47, 68-76	24470	50	464
17	103-109, 111-115	14541	30	494
18	13, 48-51, 59, 60	8191	17	511
19	61-67, 110	9899	20	531
20	14	131	2	533
21	52-58	12548	26	559
22	159, 175, 277	7564	16	575
23	147	1719	4	579
24	148-156, 164	13750	26	605
25	157, 158, 160-163, 166-169	13520	28	633
26	171, 172, 174, 261-263, 268, 269, 275, 276	20852	42	675
27	189-191, 200-203	7891	15	690
28	204-208, 218-224	14139	29	719
29	227-230	6190	13	732
30	176	1014	4	736
31	177-188	19719	40	776
32	192-199, 264-265	18254	37	813
33	209-217, 225, 226, 266, 267	17161	35	848
34	231	373	2	850
35	165, 170, 173	5407	10	860
36	St. Albert	-	15	875
37	Sherwood Park	-	15	890

TABLE F - 2

TABULATION OF RETURNS

Neighborhood	Mailing Size	Undeliverables	Number of Replies	Reply Percentage
1	2	0	1	50.0
2	32	7	10	31.2
3	38	2	15	39.4
4	20	1	12	59.9
5	21	1	7	33.3
6	26	2	15	57.6
7	18	1	10	55.5
8	5	0	3	60.0
9	8	0	4	50.0
10	35	6	14	40.0
11	57	3	26	45.6
12	37	9	12	32.4
13	36	11	11	30.5
14	33	2	15	45.5
15	46	4	14	30.4
16	50	7	13	26.0
17	30	5	4	13.3
18	17	1	5	29.4
19	20	2	4	20.0
20	2	0	0	00.0
21	26	0	7	26.9
22	16	1	9	56.1
23	4	0	4	100.0
24	26	9	6	23.1
25	28	2	10	35.7
26	42	3	19	45.2
27	15	2	7	46.6
28	29	4	5	17.2
29	13	1	5	38.4
30	4	2	1	25.0
31	40	4	18	45.0
32	37	3	15	40.6
33	35	2	15	42.9
34	2	1	0	00.0
35	10	2	3	33.3
36	15	0	8	53.3
37	15	0	9	60.0
	890	100	336	37.8

TABLE F - 3

EDMONTON SHOPPING CENTER DATA

	Gross Size (sq. ft.)	Number of Tenants	Land Size (acres)	Number of Parking Spaces	Age of Center (years)
Bonnie Doon	314,919	30	38.3	2,500	12
Capilano	328,704	48	37.0	2,700	5
Centennial	300,000	40	21.9	1,650	4
Meadowlark	250,000	70	22.0	1,600	8
Northgate	250,000	26	25.5	2,000	6
Park Plaza	178,216	16	-	1,032	11
Westmount	338,000	40	30.7	3,000	16
Southgate	685,000	48	40.0	3,500	1
Downtown	1,534,000	-	100.0	5,500	-

TABLE F - 4

TRAVEL TIMES FROM NEIGHBORHOOD i TO CENTER j

Neighbor- hood	Shopping Center								
	^a <u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>
1	25 ^b	10	19	14	31	21	10	29	16
2	24	11	24	8	30	20	5	21	20
3	30	16	29	5	31	20	9	21	20
4	25	18	34	5	33	22	12	19	26
5	24	8	14	19	28	17	17	26	11
6	21	5	19	13	23	17	11	22	14
7	25	11	27	7	29	17	11	19	19
8	26	9	25	10	26	12	11	22	22
9	26	13	27	8	31	19	14	19	16
10	21	7	17	15	23	13	15	22	11
11	29	13	8	26	25	21	23	29	13
12	19	10	14	20	19	10	17	20	8
13	13	12	19	18	14	6	17	16	11
14	26	23	8	35	23	22	35	33	15
15	23	22	7	32	19	19	32	30	14
16	19	17	11	28	17	14	22	25	8
17	11	13	14	24	13	6	23	17	11
18	17	22	14	32	16	16	30	29	12
19	13	17	15	32	11	13	28	25	12
20	25	27	17	40	17	21	31	34	16
21	19	25	20	38	22	24	37	31	18
22	21	25	38	19	29	23	26	10	28

TABLE F-4 (Continued)

Neighborhood	Shopping Center								
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>
23	13	12	25	20	19	14	19	12	17
24	10	16	25	19	17	11	26	11	17
25	13	17	26	16	22	17	24	8	21
26	20	23	31	22	26	22	30	5	26
27	5	19	23	28	9	11	26	19	18
28	8	22	28	23	15	14	31	12	23
29	10	26	30	26	16	18	34	11	26
30	14	25	33	23	22	21	31	9	28
31	11	28	23	35	6	16	33	26	18
32	8	25	28	33	5	16	31	22	23
33	5	25	30	34	10	16	32	17	25
34	11	31	33	39	9	20	37	19	28
35	12	23	28	21	20	17	29	7	23
36	39	23	29	34	43	32	32	41	26
37	21	41	43	49	19	27	39	30	33

^a The shopping centers are as follows:

- | | |
|--------------------|-----------------------|
| 1. Bonnie Doon | 6. Downtown Edmonton |
| 2. Westmount | 7. Centennial Village |
| 3. Northgate | 8. Southgate |
| 4. Meadowlark Park | 9. Park Plaza |
| 5. Capilano Mall | |

^b The distance measures are in minutes

APPENDIX G

CHARACTERISTICS OF THE SAMPLE

TABLE G - 1

TABULATION OF RESULTS FOR QUESTION 3

Factors Influencing Choice of Shopping Center	Numerical Response	Relative Response (percent)
Convenience	262	22.6
Price	170	14.6
Service	136	11.7
Product Quality	179	15.4
Product Variety	140	12.1
Habit and Familiarity	188	16.2
Advertising	48	4.1
Ease of Parking	16	1.4
Enclosed Mall	3	0.3
Work There	6	0.5
Integrity of Firm	5	0.4
Credit Card	5	0.4
Bus Service	3	0.3
	1161	

TABLE G - 2

TABULATION OF RESULTS FOR QUESTION 4

Information Source	Number of Times Considered Important	Number of Times Considered Most Important
The Edmonton Journal	140	115
Other community papers	18	3
TV	76	9
Leaflets	111	42
Radio	64	4
Catalogues	112	37
Friends	64	15
Comparing merchandise	74	100
Yellow pages	-	13
Consumer guides	-	6
	659	344

TABLE G - 3

TABULATION OF RESULTS FOR QUESTION 5

Shopping Habit	Percent Response
Shop alone or with spouse	76.2
Shop with whole family	23.8
Take the bus	15.3
Take a taxi	1.5
Take a car	83.2
Visit one center only	34.2
May visit more than one center	45.9
Often visits more than one center	15.6
Always visits more than one center	4.3

TABLE G - 4

TABULATION OF RESULTS FOR QUESTION 6

Number of Household Working in Excess of 4 Hours per Day	Percent Response
none	8.3
one	52.6
two	32.4
more than two	6.3

TABLE G - 5

EMPLOYMENT CHARACTERISTICS

Occupation Category	Numerical Response	Percent Response
Managerial, professional	125	38.2
Service, transportation, communication	32	9.8
Craftsmen, tradesmen	58	17.7
Clerical, sales	39	11.9
Manufacturing	7	2.1
Laborers	15	4.6
Others	50	15.4
No Answer	1	0.3

TABLE G - 6

AGE DISTRIBUTION OF SAMPLE HOUSEHOLDS

<u>Age Group</u>	<u>Number</u>
1 - 10	293
11 - 20	335
21 - 35	220
36 - 50	286
51 - 65	136
over 65	47
	1317

TABLE G - 7

EDUCATION CHARACTERISTICS

Education Level	Respondents	Education Level	Respondents
Grade 1	0	Grade 9	23
Grade 2	0	Grade 10	29
Grade 3	2	Grade 11	38
Grade 4	0	Grade 12	116
Grade 5	2	Bachelors	49
Grade 6	6	Masters	13
Grade 7	7	Ph.D.	3
Grade 8	20	No Answer	18

TABLE G - 8

INCOME CHARACTERISTICS

Income Group	Respondents
\$ 0 - \$ 3000	11
\$ 3000 - \$ 6000	50
\$ 6000 - \$ 9000	79
\$ 9000 - \$12000	86
Over \$12000	95
No Answer	6

APPENDIX H

FREQUENCY HISTOGRAMS

FIGURE H - 1

FREQUENCY HISTOGRAM OF LAMBDA FOR
CLOTHING IN EDMONTON STUDY

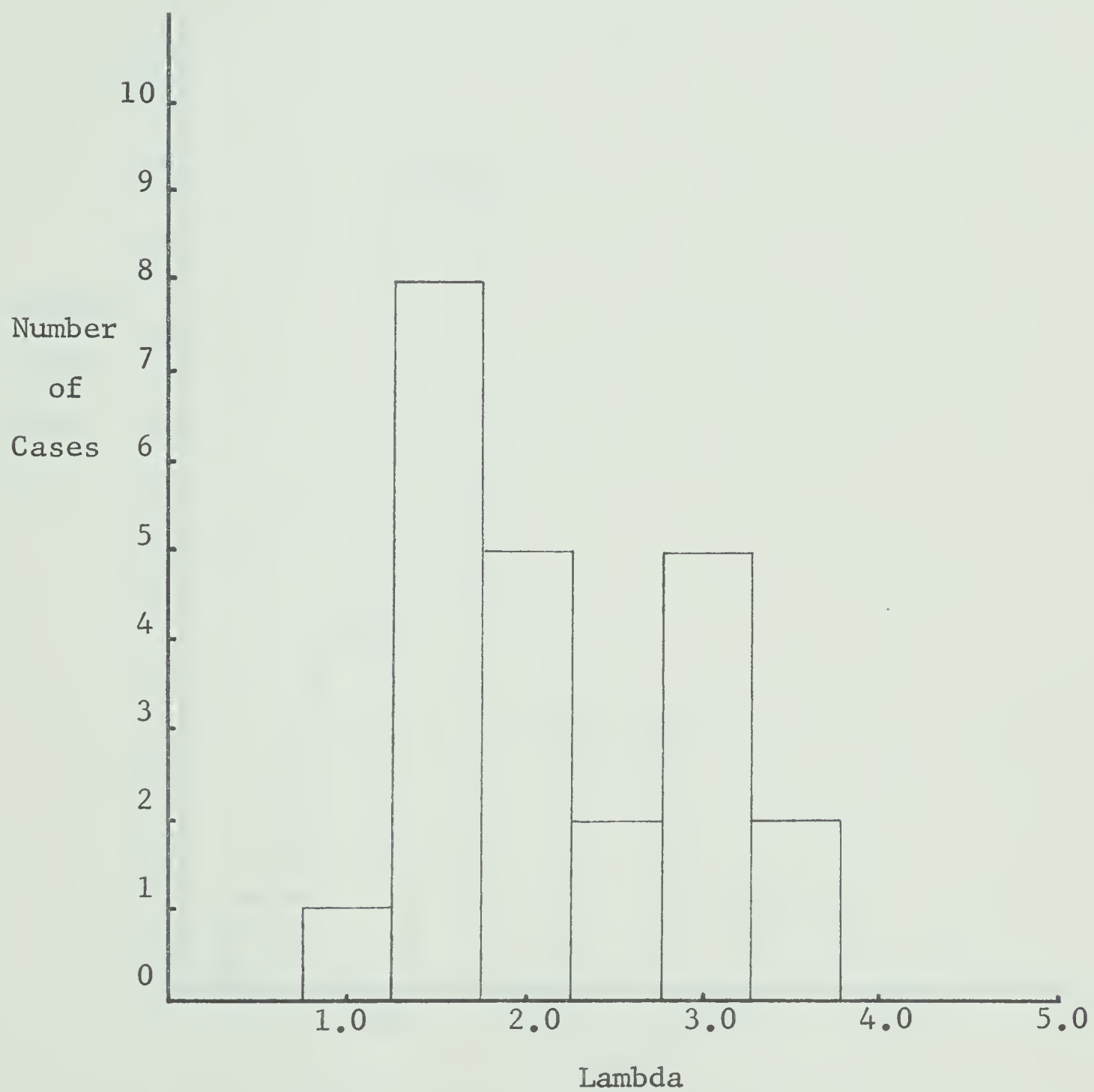


FIGURE H - 2

FREQUENCY HISTOGRAM OF LAMBDA FOR
MAJOR HOUSEHOLD GOODS IN EDMONTON STUDY

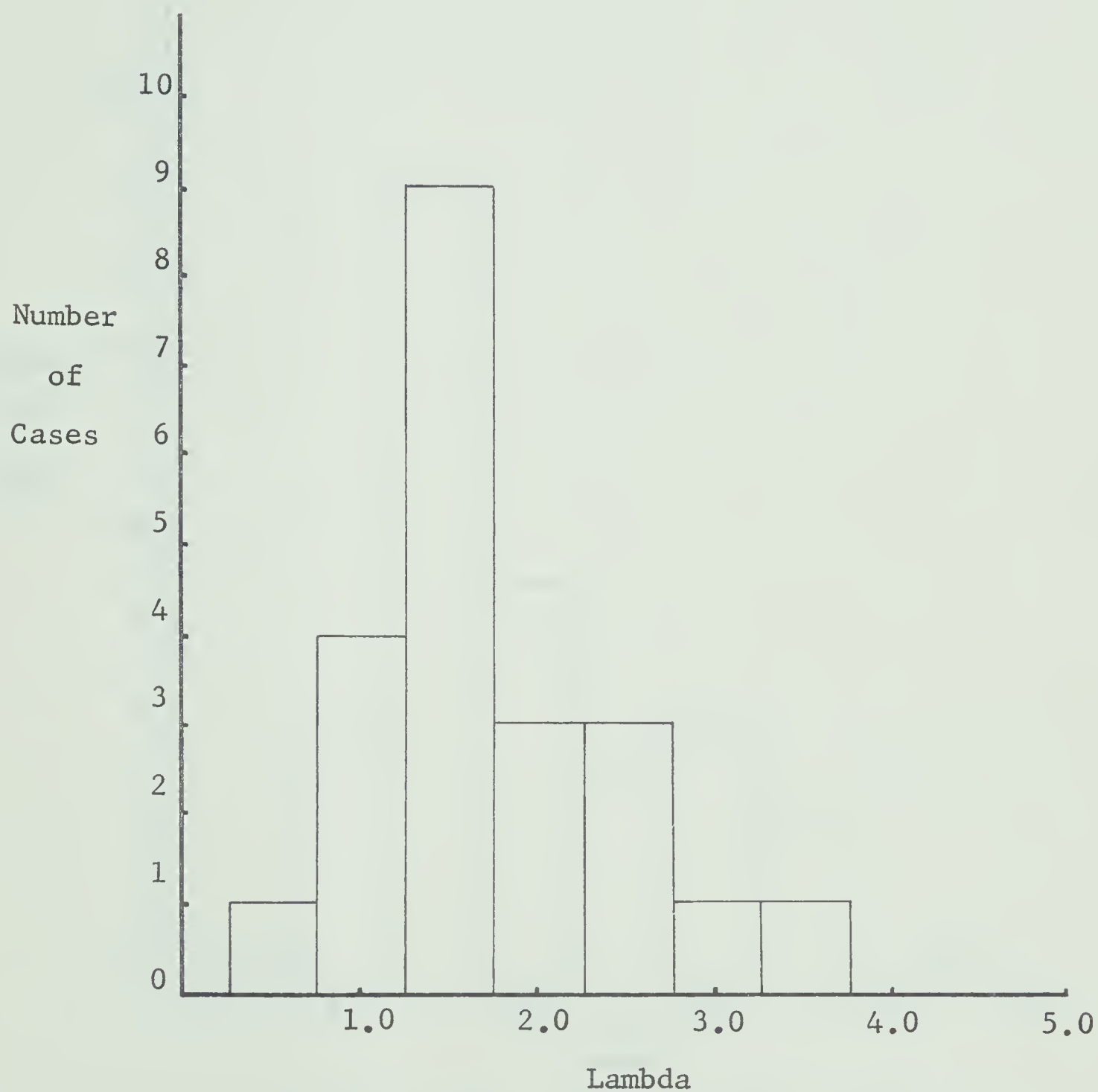


FIGURE H - 3

COMBINED FREQUENCY HISTOGRAM OF LAMBDA FOR CLOTHING

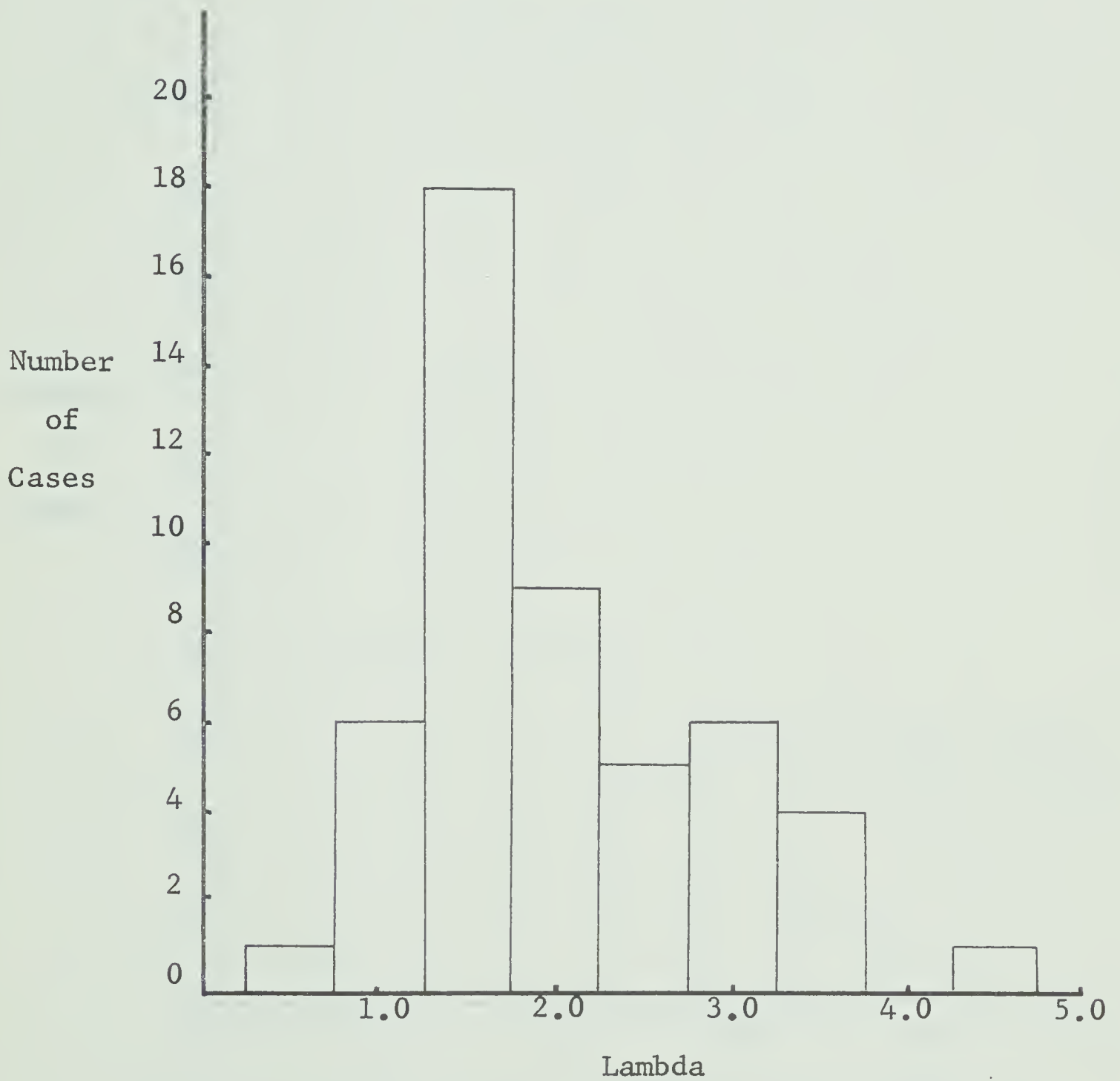


FIGURE H - 4

COMBINED FREQUENCY HISTOGRAM
OF LAMBDA FOR MAJOR HOUSEHOLD GOODS

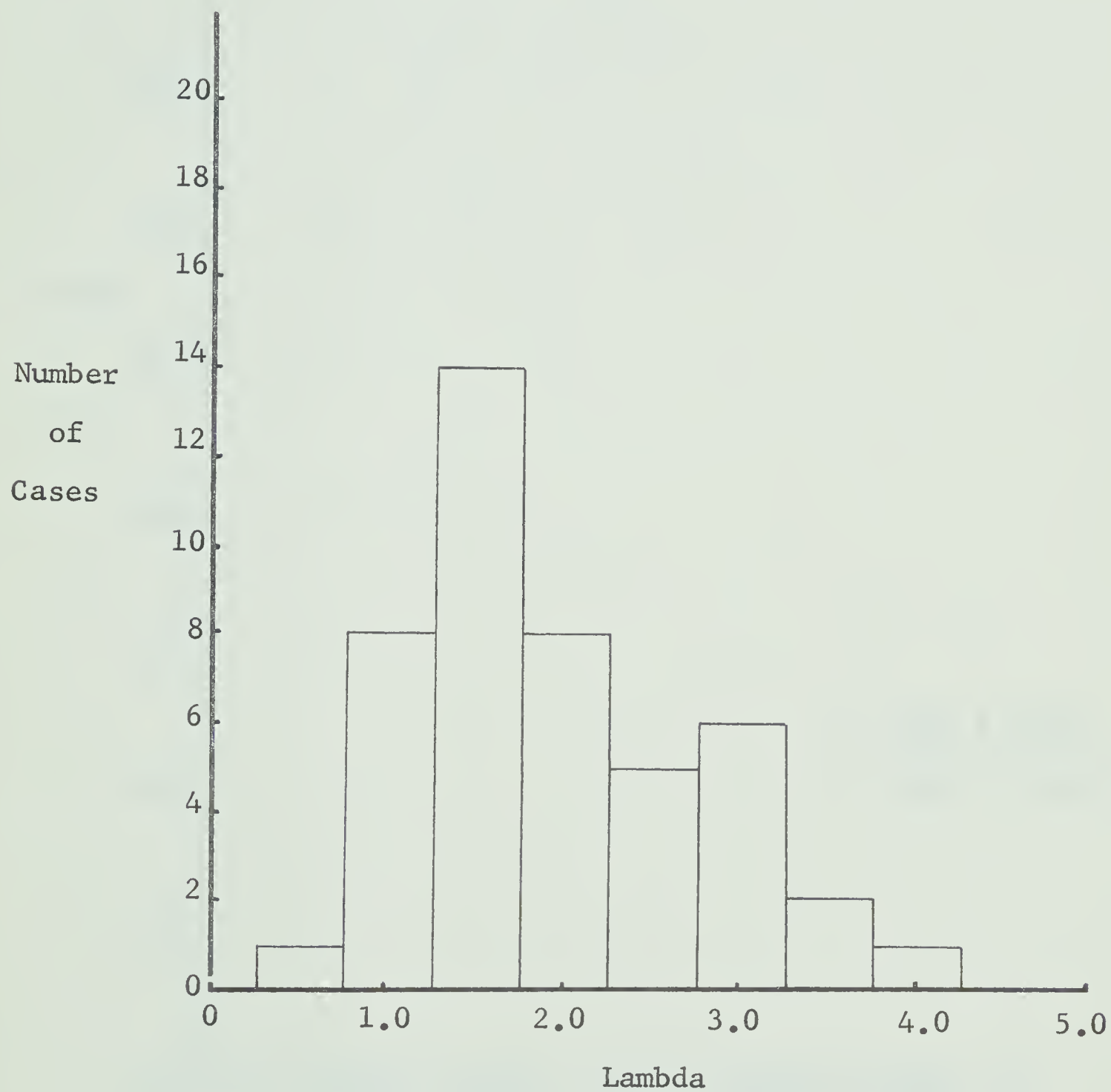


FIGURE H - 5

R MAX VERSUS LAMBDA FOR MAJOR HOUSEHOLD GOODS

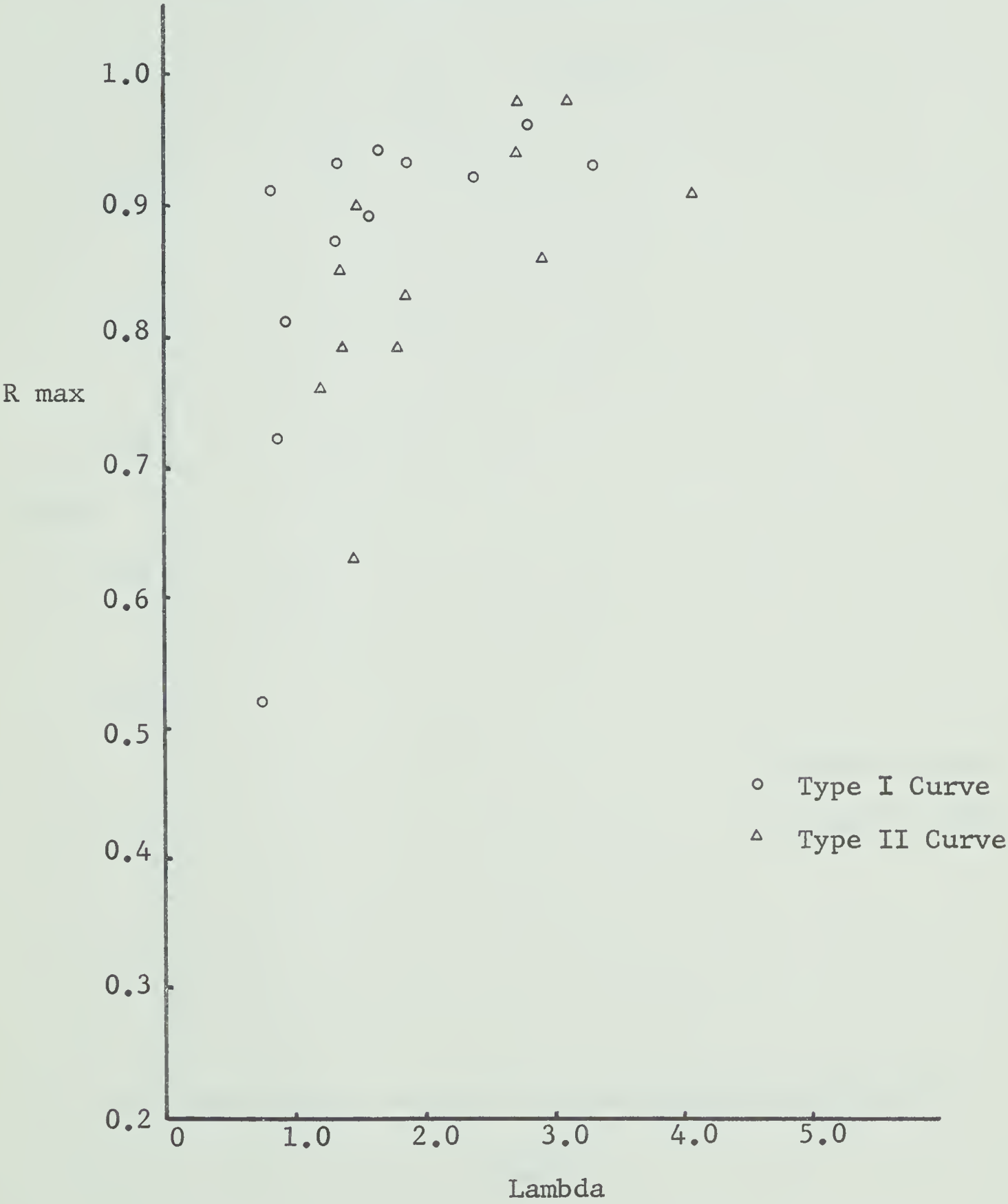
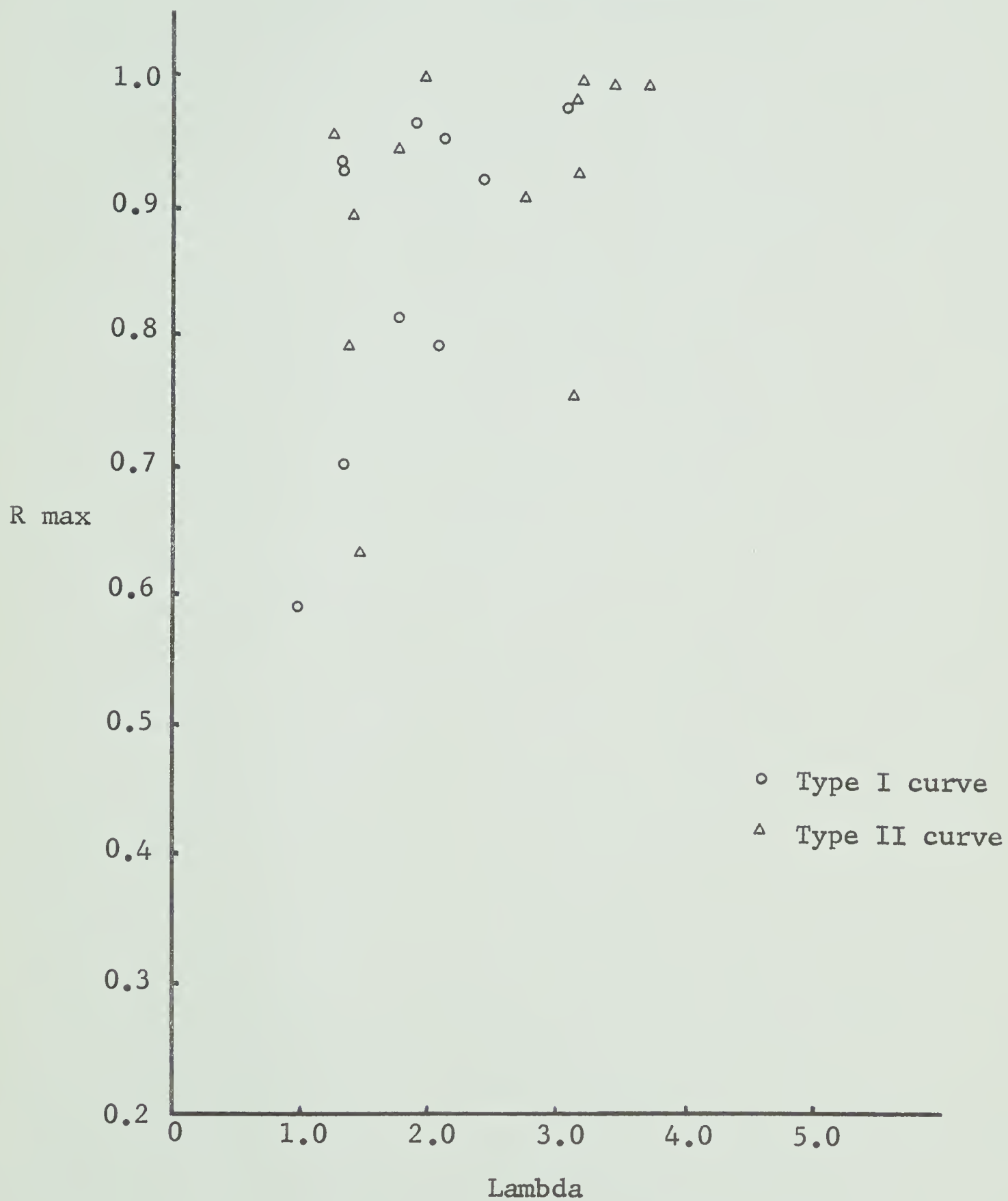


FIGURE H - 6

R MAX VERSUS LAMBDA FOR CLOTHING



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